HANDEDNESS AND SCRIPT DIRECTIONALITY IN RELATION TO GRAPHIC PRODUCTION, PERCEPTION, AND AESTHETIC PREFERENCE OF VISUAL STIMULI

An Honors Fellows Thesis

by

REBECCA ELIZABETH RHODES

Submitted to the Honors Programs Office
Texas A&M University
in partial fulfillment of the requirements for the designation as

HONORS UNDERGRADUATE RESEARCH FELLOW

April 2010

Major: Psychology

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ABSTRACT

Handedness and Script Directionality in Relation to Graphic Production, Perception and Aesthetic Preference of Visual Stimuli. (April 2010)

Rebecca Elizabeth Rhodes
Department of Psychology
Texas A&M University

Research Advisor: Dr. Jyotsna Vaid
Department of Psychology

This study examined the influence of handedness and reading/writing direction on the facing and sequencing of drawn objects and/or scenes and on orientation preference in viewing figures and photographing objects. Right- and left-handed adults who were either native readers of English or of Arabic drew 15 objects/scenes with their dominant hand and two objects also with their non-dominant hand. The objects differed in animacy, graspability, and implied motion. All participants also completed an ambiguous figure detection task in which one of the embedded figures faced leftward and the other faced rightward. In addition, right- and left-handed English readers photographed six objects in what they considered the most aesthetically pleasing orientation. A significant effect of script directionality was observed in scene depiction, with left-to-right readers depicting objects in a scene along a left-to-right axis and right-to-left readers showing the converse pattern. Ambiguous figure detection showed an overall advantage for the left-facing figure. Whereas the preferred orientation for photographing objects with implied motion was to orient them facing rightward;

graspable objects were oriented differently depending on handedness. Asymmetries in orientation of drawn objects also varied by handedness. Our research challenges a laterality-based account traditionally invoked to explain directional trends in drawing and aesthetic preference and offers support for alternative accounts that emphasize biomechanical, motor imagery, and cultural factors.

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CHAPTER I

INTRODUCTION

Drawing and cognition

Developmental psychologists have frequently studied children's drawings in order to better understand the way children represent their visual world and how this representation changes with age. By monitoring age-related changes in patterns in drawings in starting point, stroke direction, organizational layout, and/or final facing direction, psychologists can infer something about the structural development and organization of the brain. In fact, according to Van Sommers (1984), "drawing encompasses perceptual, motor, planning, representational, and pragmatic abilities." Drawing has even been compared to language, as it is a system of communication consisting of many layers (Arnheim, 1974; Gombrich, 1960; Goodman, 1968; Van Sommers, 1984). Just as in learning a language, when learning how to draw figures or objects, children learn arbitrary rules by which to represent concepts; for example, they learn that drawing an arrow upward on paper represents "up" in the air (Goodnow & Friedman, 1972). Children usually learn to apply such rules to representational drawings before they even receive formal instruction on how to write.

In his book, Van Sommers (1984) looks at a variety of aspects of children's drawings of

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This thesis follows the style of *LATERALITY*.

all types. Van Sommers notes the importance of stroke direction and the final facing of objects as indicators of the cognitive processes involved in drawing—each of these components has been proven to affect the drawing's outcome (Cox, 1992; Thomas & Silk, 1990). In particular, much research has been devoted to the final facing direction of drawn objects, and it is clear that directional patterns exist. However, the origin of these patterns is unclear. Studies typically support one of two accounts: a manual preference account (to explain the different patterns observed for right- and left-handers) and a reading/writing direction-based account (to explain differences between readers of left-to-right vs. right-to-left scripts). Some recent studies propose a joint effect of manual preference and script direction (see Vaid, 2010).

Manual preference

Manual preference has been considered in studies on directionality in drawing since Gesell and Ames (1946) found a directional trend in pre-school and school age children. Although it need not be (see Martin & Jones, 1999), manual preference is typically used as a proxy for brain laterality or cerebral functional asymmetry. Laterality refers to the relative specialization of higher cognitive functions of the right- and left-hemispheres. A vast amount of research suggests that the left hemisphere is more specialized for linguistic processing (especially in right-handers), whereas the right hemisphere is more specialized for visuospatial tasks. Given that each hemisphere also controls movements of the contralateral limbs, it is possible that left-handers have better spatial ability than right-handers (Hellige, 1993). If right- and left-handers do differ in spatial ability, it is

reasonable to assume that they may also differ in the execution of representational drawings, since spatial awareness is essential for the graphic arts (Lewis and Harris, 1990). The proposed greater spatial ability of left-handers may partially explain why there is a significantly high prevalence of left-handed architects and designers (Mebert & Michel, 1980). At any rate, because right-handers are known to be more strongly lateralized than left-handers, handedness is often used as a rough proxy for hemispheric asymmetries in cognitive functioning. Nevertheless, it should be remembered that the evidence to date does not suggest that left-handers are the opposite of right-handers in their lateralization patterns, only that they are more heterogeneous.

There is considerable support for a special role of the right hemisphere in spatial attention and processing. Much of the evidence comes from studies of patients with unilateral brain damage. A common deficit in patients with right hemisphere damage is hemi-neglect, a lack of awareness of objects in one half of their visual field. Another deficit is prosopagnosia—that is, the inability to recognize faces—a deficit that is often associated either with bilateral lesions or with lesions in the right-hemisphere, particularly in the occipital-temporal regions (De Renzi, 1986). Additionally, research with brain-intact participants has found a perceptual bias for judging symmetrical composite faces that duplicate the left half rather than the right half of the face (viewed from the perceiver's perspective) as being more like the original face; interestingly, damage to the right hemisphere eliminates this bias (Rhodes, Ronke, & Tan, 1990; Kolb, Milner & Taylor, 1983). In these studies, laterality is sufficient to account for the

findings. What is less clear is whether right vs. left hand dominance is to be taken solely as an index of laterality differences in graphic production and preference or as an index of other influences as well, such as biomechanical or cultural factors, as will be proposed in a later section.

Circle drawing

One frequent item of interest in drawing is the circle. Circles (and horizontal lines) appear in children's drawings well before children learn how to read or write. Moreover, whereas the direction in which horizontal lines are drawn is directly associated with hand used (with right hand use typically associated with left to right line drawing) the direction in which circles are drawn is less clearly tied to hand use. Research on circle drawing has examined whether people tend to draw circles clockwise or counterclockwise, whether their preference changes with age, and whether it varies with a person's handedness. The findings to date have been somewhat inconclusive. Van Sommers (1984) found that a large majority of Australian and American right-handers preferred to draw circles counterclockwise, whereas left-handers preferred to draw circles clockwise, although the effect was not as strong. However, Van Sommers also noted that Australian right-handed children initially preferred to draw circles clockwise, but switched to a counterclockwise rotation somewhere between the ages of 3 to 6. Glenn, Bradshaw, and Sharp (1995) found similar results for American children: younger right-handed children drew circles in a clockwise direction and switched to a counterclockwise direction by 5 years of age, whereas left-handed children initially drew

circles counterclockwise and switched to a clockwise direction by 10 years of age. These studies suggest that the relationship between manual preference and circle drawing direction may change with age (see also Taguchi & Noma, 2005).

Drawing ability

Vlachos and Bonoti (2004) studied right and left handed children's drawing ability. Their participants were asked to draw a series of objects, including a man, a house, a man inside a boat, and a tree in front of a house. Each drawing was scored on a scale from 1 to 4, with 1 being the least detailed drawing and 4 being the most advanced. For example, the 'house' item was scored lowest if it was simply an outline of a house, and highest if the house was three-dimensional with external features (windows, chimney, etc.) placed in the correct location. Vlachos and Bonoti also examined the location on the page at which children started their drawing, how they planned their movements, and their movement sequencing. Their analyses showed no significant difference in overall drawing ability between left- and right-handers, which challenges the claim that left-handers possess superior spatial capabilities. Moreover, in contrast to Van Sommers (1984), Vlachos and Bonoti found no effect of handedness on circle drawing in young children.

While the aforementioned manual preference and circle drawing studies seem contradictory, they lend credence to a theory proposed by Braswell and Rosengren (2002) that cognitive factors govern circle direction in younger children, but that as

children age they become more influenced by biomechanical factors. Biomechanical factors affect the starting point of the drawing, the hand used to draw (dominant vs. non-dominant), as well as the preferred stroke direction (outward, away from the body vs. inward, towards the body). Braswell and Rosengren also propose that a complex relationship may exist between drawing and manual preference, and that this relationship may be influenced by a variety of factors as children grow older. One of these influences may be the acquisition of directional biases arising from properties of the writing system (left-to-right or right-to-left), a variable that will be discussed in more detail in a later section.

Strength of directional preferences

As mentioned before, if laterality does influence directionality in drawing, then right-handers should show strong directional preferences when drawing and viewing objects. Alter (1989) was one of the first to formally test this hypothesis and she found a significant relationship between manual preference and object facing direction. Similarly, Karev (1999) instructed a large sample of right-handers, left-handers, and mixed-handers to draw six objects—a bicycle, a walking dog, a bus, a facial profile, an airplane, and a jug. Manual preference was assessed by self-report. The objects can be sorted into the following three categories: living creatures, transport vehicles, and static objects. Participants were to draw a sketch of each object using their preferred hand only. Similar to Alter (1989), the results showed a positive association between degree of manual preference and degree of drawing directionality. Whereas all groups showed a

leftward bias in drawing, right-handers were the most left-directed and left-handers were the least. Although Karev (1999) replicated Alter's findings he also uncovered differences in drawing direction as a function of the nature of the to-be-drawn object (e.g., the 'jug' item was oriented very differently by right vs. left handers). As a result Karev was led to propose that, in addition to laterality, drawing directionality differences between left- and right-handers may arise as a result of differences between how left- and right-handers customarily experience and interact with everyday objects (e.g., graspable objects).

Nature of the object

In Karev's study, the nature of the object to be drawn had a significant effect on its facing direction. The jug was most frequently drawn with the handle on the same side as the drawer's dominant hand. In other words, right-handers were more likely to draw a jug with the handle on the right-hand side, presumably because that is how right-handers are used to interacting with a jug (a concept foregrounded in Motor Image Theory, which will be addressed later). Interestingly, Karev's results on drawing direction were also consistent with one of Alter's (1989) previous findings: pictures with implied motion directed to the center (from right-to-left) were aesthetically preferred by right-handers over those with implied motion directed away from the center (from left to right). However, it is not clear in which direction the causal arrow points: do people draw objects the same way they prefer to view them, or do they prefer to view objects in

the same way they would draw them? This question concerning the relationship between drawing and viewing preferences will be addressed again in the next section.

While Karev (1999) clearly demonstrates that both manual preference and the nature of objects influence directionality, in order to clarify the results it should be repeated and include a condition in which subjects draw objects with their non-dominant hand. This would elucidate the influence of biomechanical factors and may clarify the relative contributions of perceptual and motor activities in drawing. If drawing a jug with the non-dominant hand results in a reversed directionality, this would suggest that people draw objects not in the way they prefer to view them, but in the way that is mechanically easiest. From a biomechanical perspective it is easier to execute outward than inward directed movements; thus, an object such as a car when drawn with the right hand would tend to be drawn with left-to-right stroke movements (and would presumably end up facing leftward assuming the front portion of the object is drawn first) whereas the same objects drawn with the left hand would tend to be drawn with right to left stroke movements and would end up facing rightward.

Motor Image Theory

Viggiano and Vannucci (2002) examined the relationship between drawing and identifying objects. They made reference to a theory first proposed by Martin and Jones (1999), namely, the Motor Image Theory, in interpreting their results. The Motor Image Theory proposes an isomorphism between the structure of a physical motion (such as holding a teapot) and the mental representation of that motion. In other words, the same

neural mechanisms that are involved when specific movements are made are said to be involved in the conceptualization of those movements, even if the movements themselves are absent. This theory predicts that, when imaging an object (again, such as a teapot), the object is stored in the same spatial position and direction that the person typically interacts with it. In our example, a left-handed person should image a teapot in the same position that he/she typically reaches for the teapot.

Viggiano and Vannucci (2002) tested this theory in two experiments. In the first experiment, the role of manual preference in drawing directionality was examined as participants were asked to draw a series of objects with their preferred hand. The objects were divided into five semantic categories: animals, vegetables, tools, vehicles, and furniture. The direction of facing of each object was recorded and analyzed. Viggiano and Vannucci found a significant effect of manual preference only for animals and vehicles, the two categories that involve motion. In these two categories, the anterior part of the object was drawn preferentially leftward in right-handers but rightward in left-handers. While these results show a relationship between manual preference and directionality for certain semantic categories, they cannot be explained by the conventional account proposed by Van Sommers (1984). Van Sommers accounted for directionality in terms of graphic and execution factors, such as the starting point on the page and the direction of stroke sequencing. By contrast, the results from Viggiano and Vannucci (2002) suggest that drawing directionality is also, and perhaps primarily,

dependent on semantic category, rather than biomechanical factors, and on the way we internally represent visual stimuli.

In their second experiment, Viggiano and Vannucci (2002) asked a new set of participants to identify a series of asymmetric objects taken from the same set as the first experiment. Each object was visually presented in an ascending sequence with more and more of the object gradually displayed, in order to discourage top-down processing. Further, each object was presented either facing leftward or rightward. According to a Motor Image account, processing of mobile objects (animals and vehicles) should be faster and more accurate when the objects are presented in the preferred canonical view for each manual preference group which, based on their previous experiment, was left-facing for right-handers and right-facing for left-handers. No effect of object facing was predicted for the immobile objects. The results confirmed their hypothesis; right-handers showed reduced perceptual identification thresholds for identifying leftward facing mobile objects than rightward facing objects, whereas left-handers showed the opposite pattern. For immobile objects, no differences were found between rightward and leftward presentations for either right-handers and left-handers.

The results from the second experiment in Viggiano and Vannucci (2002) suggest that directionality in drawing and identification is a result of more than just neuromuscular biases. Drawing is an activity that requires spatial representation and planning; therefore, accounts of drawing directionality must also consider the role of mental imagery,

particularly when the drawn object implies some direction of motion. One question that arises from Viggiano and Vannucci's research is: what other kinds of factors besides implied movement could affect the way we image visual stimuli? It has been suggested that reading/writing direction affects the way we enter and organize our visual world (Gaffron, 1950), and it is possible that this cultural factor also influences the direction in which we mentally picture objects.

Reading/writing habits

A laterality account cannot adequately explain many of the directionality effects in drawing described above, which clearly implies that there are additional factors to consider. A second account alluded to earlier—that is, a reading/writing direction account—predicts that prolonged experience in reading/writing a language that is written from left-to-right (as in English) versus from right-to-left (as in Arabic) exerts a dominant influence on the planning, organization, and final orientation of drawn objects. Although several authors have acknowledged that reading/writing habits are a plausible variable affecting directionality effects, remarkably little research has actually tested this claim by comparing readers of scripts with different directionality. In Vaid, Singh, Sakhuja, and Gupta (2002), a drawing task was given to readers of Hindi and Urdu, languages which are practically identical on the spoken level but are written in two very different scripts with opposite script directionalities. Each language group consisted of both left- and right-handers, so that the interaction of reading/writing habits and manual preference could be examined. A group of illiterate Hindi/Urdu speakers was also

included. For each group, the stroke direction was the primary variable of interest. It was expected that, if only handedness and biomechanical factors influenced stroke direction, then right-handers should produce more drawings with a left-to-right stroke direction and left-handers should produce more drawings with a right-to-left stroke direction. Conversely, if only reading/writing direction influenced stroke direction, then readers of Hindi (a language with left-to-right script direction) should use a predominantly left-to-right stroke direction and readers of Urdu (a language written with a right-to-left script direction) should use a predominantly right-to-left stroke direction, regardless of manual preference. Participants were instructed to sketch 6 items—a tree, a hand, a house (used as fillers) and an arrow, a pencil, a fish—with their preferred hand. Vaid et al. (2002) found that, for the illiterates, biomechanical principles influenced stroke direction as right-handers showed a left-to-right movement bias, whereas left-handers showed a right-to-left stroke direction bias. However, for literate participants, among the right-handers, readers of Hindi tended to draw objects from left to right whereas readers of Urdu tended to draw objects from right to left. These results show that reading/writing direction does exert an influence on stroke direction and, consequently, object facing direction (more recent evidence by Vaid with an extended sample of Hindi, Urdu, and Arabic right- vs. left-handed readers corroborated this overall pattern and also found support for differences within participants as a function of hand used; see summary in Vaid, 2010). Thus, it is clear that reading/writing habits cannot be ignored when studying directionality in drawing, and studies that point to a laterality explanation as the sole factor do so at the risk of ignoring the influence of cultural factors.

Left and right bias in the universe

Extrapolating beyond directionality in representational drawings, Gross and Bornstein (1978) explored the possibility that there is an inherent ‘left’ and ‘right’ in the universe. Evidence of this trend stems from developmental problems such as mirror image confusion, which is often manifested in children with reading disability in the form of letter reversal. Children with mirror image confusion have a difficult time distinguishing between the letters ‘b’ and ‘d’. It is suggested that this confusion results from the way we process and organize visual information. Gross and Bornstein explore two domains in which ‘left’ and ‘right’ directionality and mirror image confusion seem to play a significant role: dyslexia and art.

Multiple accounts of dyslexia have attributed the disability to dominance of one cerebral hemisphere over the other. As mentioned previously, in right-handers the left-hemisphere is specialized for language, whereas the right-hemisphere is better at performing visuo-spatial functions such as facial recognition, reading, and interpreting maps. Gross and Bornstein (1978) argue that equation of mirror images is most likely a right-hemisphere function. Because of this, it is plausible to suppose that dyslexia is one result of a greater dominance in the non-language hemisphere which, especially for right-handers, is the right-hemisphere. In other words, people who suffer from dyslexia may simply be better at reversing mirror-images. If this hypothesis is true, it successfully accounts for slower acquisition of reading skills (a left-hemisphere function) as well as a stronger tendency to equate mirror images and weaker ability to distinguish between

them. Additional support for this theory comes from the observation that dyslexic children are reportedly more artistic than normal children; again, this may be explained by positing that dyslexic children show cerebral dominance for language in the "non-language" right hemisphere.

Directionality and mirror image confusion also have an influence in art—there appears to be a natural 'left' and 'right' in pictures and paintings. Proponents of this 'left' and 'right' theory in art include Wolfflin (1941) and Gaffron (1950), who argued that mirror-reversing a painting would dramatically change its meaning. However, evidence for this has come only from highly asymmetrical paintings, in which mirror-reversal does produce an obvious and significant alteration; in most cases, research has shown that mirror-reversing a painting does not appear to change its content or meaning (Schwartz & Hewitt, 1970). Nevertheless, the more general observations made by Wolfflin (1941), Gaffron (1950) and Arnheim (1974) that there exist perceptual differences associated with the right and left side of visual space have received support. For example, objects that are presented in the right visual field tend to be perceived as more distant, larger, and more noticeable, whereas objects presented in the left visual field tend to look closer and clearer (Adair & Bartley, 1958; Dallenbach, 1923; Levy, 1976).

Right is good, left is bad?

Research has also suggested that the abstract ideas of 'right' and 'left' receive different affective responses. Conventionally, right is seen as "good" and left is seen as "bad," and

this pattern is evident across cultures (Davidson, 1992; Schiff & Bassel, 1996). It is unclear where this convention arose from, although it is possible that it is rooted in linguistic history. The Latin word for left, *sinister*, means "evil," whereas the Latin word for right, *dexter*, means "skillful." It is also possible, however, that the universal preference for rightward direction over leftward direction results not from linguistics but from a pervasive association between the right-hand and the right-side of space, due to the predominance of right-handers in the worldwide population. Casasanto (2009) proposed the *body-specificity hypothesis*, which asserts that abstract mental representations are a reflection of the way people interact with their physical surroundings. Somewhat reminiscent of Martin and Jones's (1999) Motor Image Theory described earlier, the body-specificity hypothesis suggests that right- and left-handers create different representations of 'right' and 'left' because they have more experience with one over the other. In Casasanto's study, right- and left-handed participants were asked to indicate which potential job candidate they were more likely to hire: the job candidate described in the left column of the page or the job candidate described in the right column. Remarkably, left-handers significantly preferred the job candidate presented on the left side of the page and right-handers significantly preferred the job candidate presented on the right side of the page. An additional task was also given in which participants had to indicate which shopping item they were more likely to buy, and similar results were found.

Portraits

Research on visual preferences has found clear directional patterns in portraits. Portraits seem to show a cheek bias—that is, portraits tend to show either more of the left cheek or more of the right cheek. More specifically, studies have shown that the left-cheek portrait is more common than the right-cheek portrait and that this left-cheek bias is stronger for portraits of women than portraits of men (McManus & Humphrey, 1973). Several accounts have been proposed to explain this. One account suggests that different posing orientations of the portrait sitter reflect different emotions, due to perceived left vs. right asymmetries in facial characteristics. For example, previous studies have shown that the right side of the face is perceived as more public, expressing vitality and power, whereas the left side of the face is perceived as more private, expressing individual characteristics (Wolff, 1933). It is possible that this asymmetry of emotional expressions contributes to a bias in a subject's pose when asked to sit for a portrait.

Posing orientation and emotion

Nicholls, Clode, Lindell, and Wood (2002) asked one group to pose in a position that showed as much emotion as possible and a second group to pose as scientists in a position that showed as little emotion as possible. The researchers found that the "emotion" group showed a left-cheek bias, whereas the "no-emotion" group showed a right-cheek bias. These results agree with those observed in Wolff (1933). Cate (2002) elaborated on the previous study and sought to determine the relationship between posing orientation and emotions perceived by the viewer (in contrast to the previous

study, in which the participants themselves were the ones asked to pose). If posing orientation of scientists has a relationship to emotions expressed and perceived by viewers, then right-cheeked portraits should be considered more ‘scientific’ than left-cheeked portraits. Cate collected a series of portraits of European professors from 1566 to 1956 and denoted the posing orientation and direction of illumination for each one, and found that the right-cheek orientation dominated among male university professors up until 1900, when there was a gradual shift toward left-cheek orientation. Cate also found that right-cheeked portraits were thought to be more scientific than left-cheeked portraits. This finding confirms the hypothesis that posing orientation for portraits can be used to convey emotional messages. Moreover, studies similar to the aforementioned have found that right-cheeked male portraits are more socially appealing than left-cheeked ones (Schirillo, 2000) and right-cheeked female portraits are more likeable and attractive than left-cheeked ones (Zaidel & Fitzgerald, 1994). These results also suggest that, if subjects are instructed to orient another face themselves, the orientation they choose may depend on how much emotion they are seeking to convey. This concept will be returned to later.

Handedness and reading/writing direction in aesthetic preference tasks

Aesthetic preference studies are not limited to oil-painted portraits; any picture containing asymmetrical content may be preferred in a specific orientation. Accounts of universal anisotropy—the act of preferring one direction over the other—fall into one of two accounts. Like drawing directionality, visual anisotropies most likely reflect either a

lateralization of brain function or the influence of cultural habits, such as reading/writing direction.

Manual preference

As mentioned before, the right hemisphere specializes in visuo-spatial functions and face recognition, so facial information that is presented in the left visual field is, theoretically, accessed more readily and accurately. Additional support for the face recognition localization claim comes from studies that show how, when people view the front of a face, they think the left-half of the face looks more like the person than the right half (Gilbert & Bakan, 1973). Furthermore, it is reasonable to assume that information that is processed more easily is therefore more pleasing to look at. It is also reasonable to suppose that this lateralization-induced preference for the left side of the visual space extends beyond portrait paintings and into any type of picture or artwork.

Reading/writing habits and the scanning glance curve

Another account for visual anisotropies, however, proposes that they are the result of cultural conventions. Wofflin (1941) proposed that people follow a habitual scanning glance curve when they enter a picture, starting on the left and moving over to the right side. This glance curve may account for certain artistic trends, such as the perception that movement from Fleft-to-right in a painting is perceived as faster and attacking (and, in contrast, movement from right to left is perceived to convey withdrawal). It should be noted that the glance curve notion has been based primarily on Western art. The

scanning glance curve also has manifestations outside of the visual arts. In Western theater, the right stage (audience left) is thought to elicit more attention, and audience members show a tendency to look to the left as the curtain rises (Dean, 1946). In Chinese theater, however, the tendency may be reversed. The habitual glance curve, then, may be considered a covert scanning mechanism that is most likely established by reading habits.

Scanning bias and aesthetic preference

If people do possess a scanning bias based on the direction in which they read, as suggested by Gaffron (1950), then reading/writing direction should exert a heavy influence on aesthetic preference. De Agostini and Chokron (2000) investigated this possibility. They tested French left-to-right readers and Israeli right-to-left readers in an aesthetic preference task, controlling for gender and age. All of the participants were right-handed and monolingual. The stimuli used were mirror-image pairs of static and mobile object pictures presented one above the other. Another set of stimuli consisted of pictures of landscapes in which the element of interest was located on either the left or right side of the picture. De Agostini and Chokron hypothesized that, if hemispheric factors alone determine aesthetic preference, then all participants should show identical left-to-right directional aesthetic preferences, regardless of reading habits. However, if reading habits also influence aesthetic preference, then participants should prefer pictures whose directionality is congruent with their reading habits. The results showed that reading habits had a significant effect on directionality; left-to-right readers

preferred the left-to-right directionality and right-to-left readers preferred the right-to-left directionality. These results were significant for both static and mobile objects, suggesting (in contrast to the claims made by Viggiano and Vannucci, 2002) that the nature of the object did not influence aesthetic preference.

The results from this experiment suggest that reading habits do influence our visual perception and, like the previously mentioned studies on drawing directionality, should not be excluded from studies on aesthetic preference. They may influence where we direct our attention, how we organize our visual world, and how we mentally represent the world. To strengthen the results of de Agostini and Chokron (2000), it is important to include left-handers in the methodology. If reading habits do exert more influence over aesthetic preference than handedness, then we could expect both right-handers and left-handers of the same reading habits to show the same aesthetic preferences.

To determine the contribution of manual preference and reading/writing habits to aesthetic preferences, Nachshon, Argaman, and Luria (1999) tested both left- and right-handers with opposite reading habits in a study measuring aesthetic preference of left and right facial profiles. Participants were two groups of right-to-left readers -- Arabic and Hebrew – and one group of left-to-right readers - Russian. Participants were shown mirror-image pairs of facial profiles drawn from actual works of art, presented side by side, and asked to indicate the more beautiful profile in each pair by writing either “L” or “R”. The results showed that reading habits had a significant effect on profile preference.

Arabic and Hebrew readers preferred leftward profiles whereas Russian readers preferred rightward facing profiles. These findings support Gaffron (1950) and suggest that people do have a scanning strategy when they view a picture, and visual stimuli that are directed along this scanning curve are considered more aesthetically pleasing than those that are directed against this scanning curve. Therefore, according to this account, people who read from left-to-right should prefer facial profiles that face rightward because they are congruent with the natural scanning bias. The findings from Nachshon *et al.* should be tested further by including other types of directional visual stimuli, such as vehicles. If people do prefer visual stimuli in directions consistent with their scanning bias, then we would expect left-to-right readers to prefer vehicles facing rightward and right-to-left readers to prefer vehicles facing leftward. Including different types of directional visual stimuli in aesthetic preference tasks would strengthen Nachshon *et al.'s* reading-scan-based interpretation of their findings.

Compositional aspects

When individuals indicate a preference for a particular orientation of a picture over its mirror image, it is important to consider the influence of other compositional aspects, such as whether or not there is a presence of a frame, whether there is a single or two objects to be drawn in a frame, and whether an object is being compared to another object on the horizontal or vertical axis (e.g., Palmer, Gardner, & Wickens, 2008). Although few studies have considered the interaction between these various compositional aspects, examining such interactions could explain some of the

inconsistent results that have found no relation between picture drawing asymmetry and picture preference (McLaughlin, Dean, & Stanley, 1983; Freimuth & Wapner, 1979).

Selection of pictures

Another important variable that has been noted in past studies is the method of selection of pictures used in the study. When pictures are selected solely on the basis of asymmetrical content, such as in McLaughlin et al. (1983), there appears to be a weaker relation between picture asymmetry and preference. However, when pictures are pre-selected by right-handers who prefer the picture significantly in one orientation, there appears to be a strong relation between picture asymmetry and preference. Banich, Heller, and Levy (1989) sought to examine the influence of these selection methods on the strength of the relation between asymmetry and preference. They hypothesized that, for pre-selected pictures that right-handers prefer in one direction, there should be a strong relationship between orientation preference and picture asymmetry, and all types of asymmetry should be relatively concordant. Conversely, for pre-selected pictures chosen only on the basis of asymmetric content, there should be a weak relationship between orientation preference and picture asymmetry, and right-handers preference should be related to both asymmetry of content and asymmetry of motion.

Interaction between asymmetric content and compositional aspects

Banich, Heller, and Levy (1989) found that right-handers favor slides with right-biased content and right-to-left motion, whereas left-handers' preference is random. Also, when

asymmetric information is concordant, such as right-biased and right-to-left motion, subjects prefer to view that picture in a particular orientation. These results slightly contradict previous results reporting that people prefer implied motion from left-to-right, congruent with habitual scanning biases. One explanation for this difference is that people may prefer right-to-left motion only when the important content is displaced to the right. In this case, the direction of motion brings the eye back toward the center; perhaps people prefer to view pictures in which the attention is directed at the center. Nonetheless, the most important finding of this study was that right-biased asymmetric content alone cannot predict right-handers' preference for pictures. Rather, it is the interaction between various asymmetric compositional aspects, such as content and direction of motion, which determines how people perceive a picture.

A more recent approach to studying asymmetries in aesthetic preference, and one that we have adopted in the present research, asks participants to photograph actual objects in whatever orientation they find pleasing. Palmer et al. (2008) used this procedure with right-handed readers of English and found an overwhelming preference for the objects to be framed facing rightward.

The present research

The present research will seek to clarify and extend previous research on directionality in drawing production, drawing perception, and aesthetic preference. Drawing production and drawing perception will be examined in a sample of right- vs. left-

handed readers of left-to-right and right-to-left scripts. Aesthetic preference will be examined in a sample of right- vs. left-handers who are readers of a left-to-right script. The following questions are examined empirically:

1) What is the relative contribution of a) the nature of an object/scene to be drawn, b) the hand used to draw, and c) prior experience with left-to-right vs. right-to-left reading/writing on object facing and stroke direction in graphic production ?

2) Is there an influence of handedness and reading/writing direction in the detection of left- vs. right-facing pictures in ambiguous figure displays?

3) What is the influence of handedness and object type in making judgments about the most aesthetically pleasing way to frame objects to be photographed?

It will be argued that a laterality account for directional effects is not the most parsimonious explanation of the observed findings; instead, alternative accounts in terms of cultural factors, such as script directionality, and the nature of the objects themselves, provide more plausible explanations of drawing directionality.

CHAPTER II

METHOD

Directionality in drawing production and figure detection

Participants

Ninety right-handed and 46 left-handed native English readers recruited from Texas A&M University and 20 right-handed and 4 left-handed native Arabic readers recruited from the Texas A&M campus in Doha, Qatar participated in the study. All participants were university students. A distribution of the sample can be seen in Table 1.

TABLE 1
Distribution of the sample used for the ambiguous figures perception and drawing production tasks

Reading Direction	Right-handers	Left-handers	Total
Left-to-right	32 M, 58 F	22 M, 24 F	135
Right-to-left	11 M, 9 F	1 M, 3 F	24

A subset of the participants (N = 135) at Texas A&M university were recruited through a psychology subject pool, through which they received course credit for participating. The remaining Texas A&M participants were recruited through classes and received extra credit for completing the study. Participants from the university in Qatar were volunteers and did not receive course credit for participating.

Manual preference was measured by the Edinburgh Inventory (Oldfield, 1971), a widely used self-report measure consisting of 10 everyday activities for which participants were to indicate whether they have a strong preference for using the right or left hand (and in some cases, eye, or foot) or whether they have no particular preference. The activities were: writing, holding a nail when hammering, throwing a ball, using a toothbrush, cutting with scissors, combing their hair, threading a needle, pouring liquid into a bottle, kicking a ball, and looking into a camera. In addition, participants were to indicate if they self-identified as right-handed, left-handed or ambidextrous, whether any members in their immediate family was left-handed, whether they had ever changed their handedness (e.g., due to an injury), and whether they write with an inverted or non-inverted hand posture. A copy of the handedness instrument is provided in Appendix-5.

Participants' language background was assessed using a detailed language background and use questionnaire adapted from Vaid and Lambert (1979); see Appendix 6. The questionnaire asked participants to rate their proficiency in speaking, reading, listening, and comprehending to each of their languages, and to indicate when and in what context each language was acquired. They were also to indicate what language(s) they typically use when speaking to parents, friends, teachers, etc., as well as what language(s) they use to express affection, pray, dream, think, tell funny stories, send e-mails, etc.

Materials and procedure

Each participant completed a packet distributed to them at the beginning of the study. Participants were free to use a pen or pencil. Each packet contained four components: the language background questionnaire, a set of line drawings of ambiguous figures, the handedness inventory, and a list of 15 items/scenes to draw. Participants completed the language background questionnaire first, followed by the ambiguous figures and the first 12 items of the drawing task. Participants then completed the handedness questionnaire and completed the remaining three items of the drawing task.

Ambiguous figures

Ambiguous figures are pictures in which more than one object is present in the picture, but only one object can be seen at a time. For each ambiguous figure presented in the study, participants were instructed to write down what they saw first when looking at the figure. Then, if they were able to see the figure in any other way, they were to write that down next. If participants were only able to see one figure, they were instructed to leave the second line blank. Two versions of the packet were created, and the order in which the ambiguous figures were presented was counterbalanced.

Drawings

The drawing production task was divided into two parts. Part I was administered directly after the ambiguous figure task. In this part, participants were asked to draw 12 items with their dominant hand. . Participants were told that they would not be evaluated on

artistic ability, and that a simple sketch would be sufficient. Specific instructions were given for each item, and each set of instructions was accompanied by a blank rectangle centered on the page, and participants were to place each drawing inside this space.

The objects selected for the study were chosen to differ on the following dimensions: moving or stationary (e.g., galloping horse), animate vs. inanimate (e.g., facial profile), and graspable vs. not graspable (e.g., teapot). In addition, some scenes composed of multiple objects were to be drawn and there were some filler items. Below is a description of each item participants were asked to draw in the order they were instructed to draw them:

1. House (scene) — participants were asked to imagine that they are standing in front of two houses. One house was close to them while the other was far away. They were asked to draw this scene and label the houses as ‘near’ and ‘far’. They were then to number the houses in the order in which they drew them.
2. Hand (filler) — participants were to draw a human hand and to indicate the thumb, and to place an X to note where they started the drawing.
3. Tree (filler) — participants were asked to draw a simple tree.
4. Horse (moving/animate) — participants were asked to draw a horse that was galloping, and were asked to place an X where they started the drawing.

5. Top (moving/inanimate) — participants were asked to imagine a top spinning on a flat surface, such as a table, and indicate which direction the top was spinning (clockwise or counterclockwise) by drawing an arrow.
6. Fish (moving/animate) — participants were asked to draw three fish that were swimming in the same direction. Participants were also instructed to number the fish in the order in which they drew them.
7. Maze (filler) — participants were provided with a maze with two possible solutions— one directed toward the left and one directed toward the right—and were asked to trace a path from start to finish.
8. Teapot (static/graspable) — participants were asked to draw a teapot and place an X where they started their drawing.
9. Car entering or leaving a garage (scene) — participants were asked to imagine themselves standing on the side of a house's driveway, watching a car *enter* the house's garage; they were asked to draw this scene and place an X to indicate where they started the drawing. Another subgroup of participants was asked to imagine that they were watching a car *leave* the house's garage; they were then asked to draw that scene and indicate where they started the drawing.
10. Moon (static/inanimate) — participants were asked to draw a crescent moon.
11. Depiction of a sentence (scene) —participants were asked to draw a representation of the following sentence: "The pen is between the candle

and the stapler" (the sentence was taken from a study conducted in right handed English readers by Jahn, Knauft, & Johnson-Laird, 2007) and were then asked to number the objects in the order in which they drew them. For the Arabic participants, the sentence was presented in translation.

12. Facial profile (animate) — participants were asked to draw a side view of a human face and put an X next to where on the drawing they began it (e.g., the forehead, the nose, etc.).

After completion of Part I, participants then filled out the handedness inventory and then began Part II of the drawing task. Below is a description of each item participants were asked to draw in Part II.

13. Circle (static) — using their dominant hand, participants were asked to draw a circle ending in an arrow.
14. Profile (animate) — participants were asked to switch to their *non-dominant* hand to draw the profile of a person's face, and place an X where they started the drawing.
15. Hand (filler) — participants were asked to continue using their *non-dominant* hand to draw a person's hand; they were then asked to label the thumb and place an X where they started the drawing.

Scoring criteria

For each ambiguous figure, the first object they saw when looking at the picture was recorded by the experimenter. For the drawing task, the facing direction (rightward vs. leftward) of each drawn object was recorded. A group of nine judges who were not aware of the research hypothesis independently scored each drawn item:

- For the *House* item, the judges determined whether the 'near' house was drawn on the left or right side of the 'far' house. If it could not be determined whether the 'near' house was on the left or right (for example, if the participant drew the 'far' house directly on top of the 'near' house), the drawing was not entered into the analysis.
- For the *Hand* items (Part I and Part II), the judges determined whether the hand drawn was a left hand or a right hand. If the nature of the hand was unclear, the drawing was not considered.
- For the *Horse* item, the judges determined whether the horse was galloping toward the left or toward the right. Any drawing in which the horse was galloping in a direction other than left or right was not considered.
- For the *Top* item, judges determined whether the top was spinning clockwise or counterclockwise.
- For the *Fish* item, judges determined whether the fish were swimming toward the left or the right, and also recorded the order in which the fish were drawn. Any drawing in which the fish were swimming in a direction other than left or right was not considered.

- For the *Teapot* item, judges determined whether the spout was facing left or right. Any drawing in which the direction of the teapot could not be identified was not considered.
- For the *Garage* item, judges determined whether the car was leaving/entering the garage rightward or leftward. Any drawing in which the direction of the car could not be considered rightward or leftward was not considered.
- For the *Moon* item, judges determined whether the crescent moon was facing leftward or rightward. 'Rightward' was defined as having both endpoints of the crescent moon facing toward the viewer's right. Any drawing in which the direction of the moon could not be unequivocally considered leftward or rightward was not excluded from the data analysis.
- For the *Sentence* item, judges determined the order in which each object was drawn, as well as whether the candle and stapler were placed to the right or left of the pen.
- For the *Profile* items (Part I and Part II), judges determined whether the facial profile was facing leftward or rightward. Any drawing in which the profile was not facing left or right was not considered.
- For the *Circle* item, judges determined whether the arrow was directed clockwise or counterclockwise; any drawing in which the arrow was not directed in either of the orientations was not considered.

Aesthetic preference task

Participants

The aesthetic preference task was administered to 69 right-handed and 38 left-handed English readers recruited from Texas A&M University. All participants were university students. A distribution of the sample can be seen in Table 2. All participants were recruited through the psychology subject pool at Texas A&M in College Station, Texas and earned credit toward their introductory psychology course by participating. All of the participants who completed the aesthetic preference task also completed the drawing task. The aesthetic preference task was administered after the drawing production task.

TABLE 2
Distribution of the sample used in the aesthetic preference task

	Males	**Females**	**Total**
Right-handers	29	40	69
Left-handers	20	18	38

Materials and procedure

While each group of participants was completing the drawing task (an average of about 8 people were tested at a time) , individual participants were approached and asked to go into the hall for a few minutes to complete a picture-taking task. During the picture-taking task, participants were asked to take a series of six photographs of selected common objects. The objects to be photographed included: an iron, a toy car, a bust of Nefertiti, a toy airplane, a teapot, and a toy rhinoceros. Like the items in the drawing task, the items selected for the picture-taking task belonged to one of three categories:

Animate (rhinoceros, bust of Nefertiti), Household Tool (iron, teapot), and Vehicle (toy car, toy airplane). Three items (teapot, bust of Nefertiti, and rhinoceros) were considered to be the same stimuli as three items in the drawing task (teapot, facial profile, and galloping horse). The preferred direction of these specific objects would be compared across each task.

Each object was presented on a rotating table, and participants were first asked to watch the object through the viewfinder of the digital camera as the experimenter rotated the object and table 360 degrees. Participants were instructed to think about what orientation looked the best as the object was rotating. After the completion of one 360 degree cycle, participants were asked to rotate the object into the most aesthetically pleasing orientation (participants were asked not to face the object directly toward them or directly away from them). When the object was in the desired orientation, participants took the photograph. The order of presentation of each object was counterbalanced.

Scoring criteria

For each of the six objects, the experimenter determined whether the object was facing leftward or rightward relative to the position of the participant. For the teapot item, rightward was defined as having the teapot's spout directed toward the right. For the iron item, rightward was defined as having the flat part of the iron directed toward the right. For all other items, rightward was defined as having the front of the object directed toward the right of the photograph.

CHAPTER III

RESULTS

Ambiguous figures

The questions of interest on this task were 1) whether there is a perceptual advantage in identifying left-facing figures in ambiguous displays containing a left-facing and a right-facing figure, 2) whether this advantage would be greater in right-handers than in left-handers, and 3) whether it would be greater in left-to-right readers than in right-to-left readers. For each ambiguous figure, percent report of the left- vs. right-facing figure was analyzed in two separate chi square analyses, one looking at performance by manual preference and the other looking at performance by script direction. Data in this section are based on a total of 90 right-handed and 46 left-handed English readers, and 20 right-handed and 4 left-handed Arabic readers. Examples of the ambiguous figures can be found in Appendix 1. A summary of the results for the ambiguous figure task can be found in Table 3 (Appendix 2).

In the duck/rabbit ambiguous figure (see Appendix 1, Figure 7), the majority of English-reading participants (61.3% of right-handers, 59.5% of left-handers) reported seeing the duck first (i.e., the left-facing figure). A chi-square analysis showed that manual preference did not have a significant influence on the object seen first (X^2= .034, p = .854). Likewise, both English and Arabic readers reported seeing the duck first; reading/writing habits did not have a significant effect (X^2 = .009, p = .925).

For the saxophone/woman ambiguous figure (see Appendix 1, Figure 8), the majority of English-reading participants (68.4% of right-handers, 55.3% of left-handers) reported seeing the woman first (the left-facing figure). Manual preference did not have a significant influence on the object seen first (X^2 = 1.904, p = .168). For Arabic and English readers, regardless of manual preference, the object seen first varied according to reading/writing direction. The majority of Arabic readers (63.2%) reported seeing the saxophone first (the right-facing figure), whereas the majority of English readers (58.5%) reported seeing the woman first (the left-facing figure). The effect of reading/writing habits on the object seen first for the saxophone/woman ambiguous figure approached significance (X^2 = 3.053, p = .081).

For the Indian/Eskimo ambiguous figure (see Appendix 1, Figure 9), the majority of English readers (90.3% of right-handers, 97.1% of left-handers) reported seeing the Indian head (the left-facing object) first. A chi-square analysis showed that manual preference did not have a significant influence (X^2 = 1.522, p = .217). Similarly, both Arabic and English readers (90% of Arabic, 96.3% of English) saw the Indian head first. Reading/writing habits did not exert a significant effect (X^2 = 1.468, p = .226).

In the angry man/liar ambiguous figure (see Appendix 1, Figure 10) the majority of English-reading participants (97.5% of right-handers, 94.7% of left-handers) reported seeing the angry man (the object facing left) first. Manual preference did not appear to have a significant influence (X^2 = .601, p = .438). Likewise, both English and Arabic

readers (100% of Arabic, 96.3% of English) reported seeing the angry man first, and there was no effect of reading/writing habits (X^2 = .772, p = .380).

In the white knight/black knight ambiguous figure (see Appendix 1, Figure 11), English-readers, regardless of manual preference, reported seeing the white horse first (88.5% of right-handers, 73.1% of left-handers). This effect approached significance (X^2 = 2.954, p = .086). Likewise, both Arabic and English readers also reported seeing the white horse first (71.4% of Arabic readers, 85.7% of English readers), although this result was not different from chance (X^2 = .987, p = .320).

In the goose/dove ambiguous figure (see Appendix 1, Figure 12), 52.7% of right-handed English participants reported seeing the dove first (the right-facing object), whereas 59.3% of left-handers reported seeing the goose first (the left-facing object). However, this difference was not statistically significant (X^2 = 1.041, p = .307). Both Arabic and English readers (100% of Arabic, 58.8% of English) also reported seeing the dove first, and reading/writing habits did not have a significant influence (X^2 = 2.054, p = .152).

For the man/girl holding mirror ambiguous figure (see Appendix 1, Figure 13), the majority of English readers (96.2% of right-handers, 97.3% of left-handers) saw the man first (the left-facing figure). A chi-square analysis showed that there was no effect of manual preference (X^2 = .098, p = .755). Similarly, the majority of both Arabic and English readers (100% of Arabic, 96.2% of English) also reported seeing the man first. Reading/writing habits did not exert an influence (X^2 = .748, p = .387).

Lastly, in the skull/woman ambiguous figure (see Appendix 1, Figure 14) the majority of English-reading participants (85% of right-handers, 92.1% of left-handers) saw the skull first (the object facing left). Manual preference did not have a significant effect (X^2 = 1.172, p = .279). In contrast, the majority of both Arabic and English readers (80% of Arabic, 86% of English) reported seeing the skull first (the object facing left). There was no effect of reading/writing habits (X^2 = .474, p = .491).

In conclusion, for the majority of the items, the left-facing figure was seen first. This tendency was equally strong in right- and left-handers, as well as Arabic and English readers. The only item for which right- and left-handers showed a hint of a difference was for the goose/dove figure, although this difference did not reach significance. The only item for which reading habits seemed to exert an influence was the woman/saxophone figure. For the majority of the items, it may be that one of the figures was simply more prominent perceptually, thereby overriding any effects of handedness or reading/writing habits. For the items in which differences were observed, the two figures may have been equally salient. A summary table for these results can be found in Appendix 2.

Graphic production task

In the drawing task, the questions of interest were: 1) How does facing direction of the drawings depend upon the subject matter to be drawn? 2) How does manual preference influence facing direction? and 3)How do reading/writing habits affect drawing orientation? In the first part of this report we will discuss the results obtained for individual objects (e.g., the horse, fish, teapot, moon, circle, and profile items), whereas in the second part we will focus on results for scene items (e.g., near house vs. far house, car entering/leaving garage, three fish swimming, and sentence depiction). Data in the drawing task section are based on 90 right-handed and 46 left handed English readers, and on 20 right-handed and 4 left-handed Arabic readers. A copy of each item used in the drawing task can be found in Appendix 3.

Objects with implied motion

The items included within this section were a galloping horse and three fish swimming in the same direction.

Horse

The majority of English-reading participants drew the galloping horse facing rightward, with an implied left-to-right direction of movement (see Appendix 3, Figure 15). Manual preference did not have a significant influence on the direction (57.5% of right-handers and 63.3% of left-handers faced the horse rightward, $X^2 = .342$, $p = .559$). Likewise, the majority of Arabic-reading participants (59.1% of right-handers, 100% of left-handers)

also drew the horse facing rightward and, again, no effect of manual preference was observed (X^2 = 2.503, p = .114). Additionally, English and Arabic readers in general showed a tendency to draw the horse rightward, and reading/writing direction did not have a significant effect (X^2 = .712, p = .399).

Three fish

The majority of English-reading participants (67.5% of right-handers, 68.4% of left-handers) drew the three fish facing rightward, swimming from left-to-right (see Appendix 3, Figure 16). A chi-square analysis showed that manual preference did not have an effect (X^2 = .010, p = .920). The majority of Arabic-reading participants also drew the fish facing rightward (63.6% of right-handers, 75.0% of left-handers), and once again manual preference did not affect the direction (X^2 = .193, p = .660). Reading/writing direction also did not significantly influence the direction in which participants chose to orient the fish (X^2 = .001, p = .978).

In summary, for objects with implied motion the results showed an overall tendency to represent motion in a left-to-right direction. Neither reading/writing direction nor manual preference appeared to exert an influence on this representation of motion.

Graspable items

Two items – a teapot and a spinning top – were included to test the effect of graspability and normal handling on facing orientation and direction of movement.

Teapot

The majority of English-reading participants (66.3% of right-handers, 75.7% of left-handers) drew the teapot facing rightward, that is, with the handle to the left and the spout to the right side (see Appendix 3, Figure 17). A chi-square analysis showed that manual preference did not have a significant influence on facing direction (X^2 = 1.055, p = .304). Likewise, the majority of right-handed Arabic readers (70.0%) tended to draw the teapot directed rightward, with the handle on the left-side. Left-handed Arabic readers (75.0%) were also likely to draw the teapot facing rightward or leftward. Again, manual preference did not significantly affect the facing direction (X^2 = 0.040, p = .841). Additionally, no difference in overall facing preference was found between English and Arabic readers (X^2 = .130, p = .718).

Spinning top

For this item (see Appendix 3, Figure 18), participants were presented with a picture of a top and were asked to imagine that they were spinning it on a table. Participants then indicated which direction the top was spinning by drawing an arrow. The majority of English-reading participants (65.0% of right-handers, 56.8% of left-handers) depicted the top spinning in a clockwise direction (i.e., left to right). Manual preference did not have a significant effect (X^2 = .733, p = .392). In contrast, among Arabic readers the preferred rotation of the top showed a trend for a difference by manual preference: most right-handed Arabic readers (52.4%) depicted the top spinning clockwise, whereas most of the left-handed Arabic readers (75.0%) depicted it spinning counterclockwise (X^2 =

1.009, p = .315). Given that the number of left-handed Arabic readers was very small, it is possible that with a larger sample the manual preference effect would have reached an acceptable level of significance. Furthermore, reading/writing direction did not have a significant influence on the imagined spinning direction of the top—both English and Arabic readers tended to imagine the top spinning clockwise.

In summary, no differences were found between left- and right-handers of English or Arabic for the facing of the teapot. Furthermore, no significant overall differences were found in facing direction as a function of reading/writing direction. Interestingly, the general tendency for drawing the direction of movement of a spinning top was from left to right. While manual preference showed a slight effect in depicting spinning direction for Arabic readers, the effect was not significant. Overall, no significant manual preference or reading/writing effect was observed for the circle items.

Circular shapes

Circle ending in arrow

In the circular arrow item (see Appendix 3, Figure 19), participants were asked to draw a circle ending in an arrow. The arrow was used to determine which direction the participant drew the circle in, clockwise or counterclockwise. The majority of English-speaking participants (84.1% of right-handers, 60.0% of left-handers) drew the circle counterclockwise. A chi-square analysis showed that manual preference did significantly influence the method of circle production (X^2 = 7.360, p = .007). Both right-handed

Arabic readers (87.5%) and left-handed Arabic readers (75.0%) also tended to draw the circle counterclockwise, and manual preference did not have a significant influence (X^2 = .392, p = .531). Similarly, Arabic readers (85.0%) and English readers (76.4%) showed an overall preference to draw the circle counterclockwise; there were no differences between Arabic and English readers (X^2 = .717, p = .397).

Crescent moon

For the moon item (see Appendix 3, Figure 20), the majority of English readers (67.1% of right-handers, 80.6% of left-handers) drew the crescent moon facing rightward, with the points on the right-side and the smooth part on the left-side. A chi-square analysis showed there were no differences between right- and left-handers (X^2 = 2.192, p = .139). In contrast, the majority of right-handed Arabic speakers (66.7%) tended to draw the crescent moon facing leftward, with the points on the left-side, whereas most of left-handed Arabic speakers (75.0%) drew the crescent moon facing rightward. The effect of manual preference on direction of facing for Arabic readers was not significant (X^2 = 2.350, p = .125). Overall, Arabic readers showed a stronger tendency to face the moon leftward (60.9%), whereas English readers tended to face the moon rightward (71.2%); this effect of reading/writing habits was statistically significant (X^2 = 8.809, p = .003).

In general, there was a tendency for both English and Arabic readers, regardless of handedness, to draw a circle counterclockwise. For the moon item, a significant difference was found between English and Arabic readers, with English readers showing

a tendency to face the moon rightward and Arabic readers tending to face the moon leftward.

Profile of a face

For this item (see Appendix 3, Figure 21), participants were asked to draw a profile of a face using their dominant hand and then a few trials later, to do the same task with their non-dominant hand. In each instance, the direction in which the profile faced as well as the starting position of the drawing, were analyzed. For each reading direction group, we tested whether profile direction varied according to the hand used.

Facing direction

When participants drew the profile with their dominant hand, the facing direction varied according to manual preference, in both English and Arabic readers. Thus, whereas over half of right-handed English readers (57.5%) oriented the profile leftward, the majority of left-handed English readers drew the profile facing rightward (73.7). A chi-square analysis showed that manual preference had a significant effect (X^2 = 10.047, p = .002). Similarly, for Arabic readers, there was a strong right-facing preference in the majority of right-handers (68.2%), whereas left-handed Arabic readers showed a rightward facing preference (75.0%). For Arabic readers the effect of manual preference did not reach significance (X^2 = 2.666, p = .102). Additionally, there was no significant difference between Arabic and English readers in profile facing direction when the data of right- and left-handers were combined (X^2 = 2.220, p = .136),

When drawing with their non-dominant hand, the patterns observed previously for profile direction reversed. The majority of right-handed English readers (65.0%) oriented the profile rightward when drawing with their left-hand, whereas the majority of left-handed English readers (52.6%) oriented the profile leftward when drawing with their right-hand. A chi-square analysis showed that manual preference did have an effect on profile direction when using the non-dominant hand, and this effect approached significance (X^2 = 3.319, p = .068). Right-handed Arabic readers (71.4%) and left-handed Arabic readers (75.0%) tended to face the profile rightward. Overall, both English and Arabic readers showed an overall tendency to face the profile rightward when drawing with their non-dominant hand, and reading/writing habits alone did not significantly affect the profile orientation (X^2 = .853, p = .356).

Starting position preference

The preferred starting position for English readers when using their dominant hand was at the forehead, irrespective of handedness (89.9% of right-handers, 87.9% of left-handers, X^2 = .108, p = .947). The same was true of Arabic readers (75.0% of right-handers, 100% of left-handers, X^2 = 1.263, p = .532). While both English and Arabic readers showed an overall preference for starting the profile at the top, the strength of this preference varied significantly according to reading/writing direction (X^2 = 7.935, p = .019): whereas English readers predominantly started the profile at the top, Arabic readers showed more variability, with some starting the profile in the middle, at the nose.

The preferred starting position when drawing with the non-dominant hand showed a similar pattern to that observed when participants drew with their dominant hand. The majority of right- and left-handers, regardless of reading/writing direction (89.9% of English right-handers, 97% of English left-handers, 84.2% of Arabic right-handers, 100% of Arabic left-handers), preferred to start the profile at the top, and manual preference did not have a significant effect. Again, while both English readers and Arabic readers tended to start the profile at the top, the strength of this preference varied significantly according to reading/writing habits ($X^2 = 13.871$, $p = .001$).

In summary, right-handed English readers tended to draw the profile facing leftward when using their dominant hand and rightward when using their non-dominant hand; left-handed English readers showed the opposite pattern. In contrast, right-handed Arabic readers tended to draw the profile facing rightward when using their dominant hand and leftward when using their non-dominant hand; left-handed Arabic readers showed the opposite pattern. Additionally, there was an overall tendency to start the profile at the forehead, but this preference was stronger in English readers than in Arabic readers.

Overall summary

Taken together, the results of the items discussed thus far (i.e., objects with implied motion, graspable objects, circular shapes, and facial profile) there was a significant

effect of manual preference on facing direction of two objects -- the facial profile and the circle ending in an arrow. Reading/writing direction, in turn, had a significant influence on the orientation of one object - the moon. Further, when depicting an object with implied movement (galloping horse), a trend for left-to-right motion was observed for both English and Arabic readers. A summary of these findings is illustrated below in Figures 1 and 2.

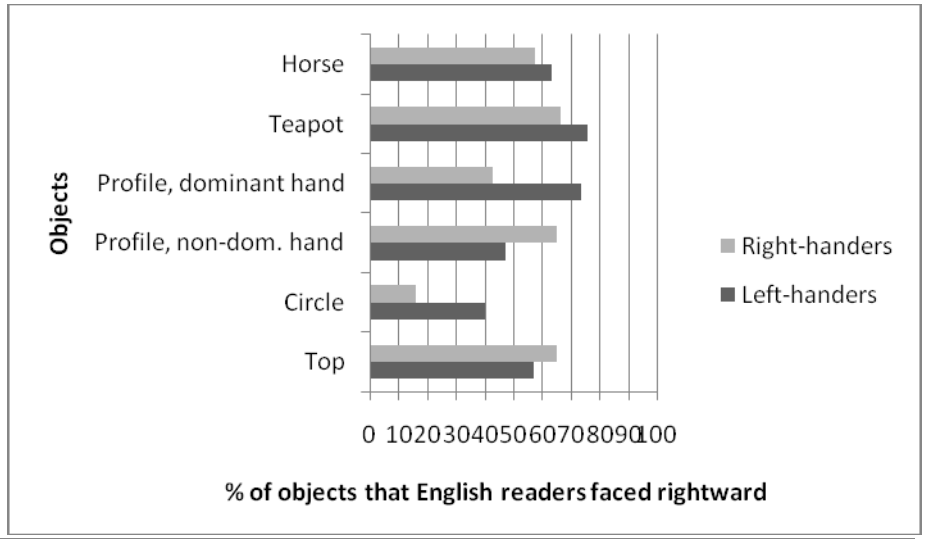

Figure 1. Directionality as a function of manual preference: English readers.

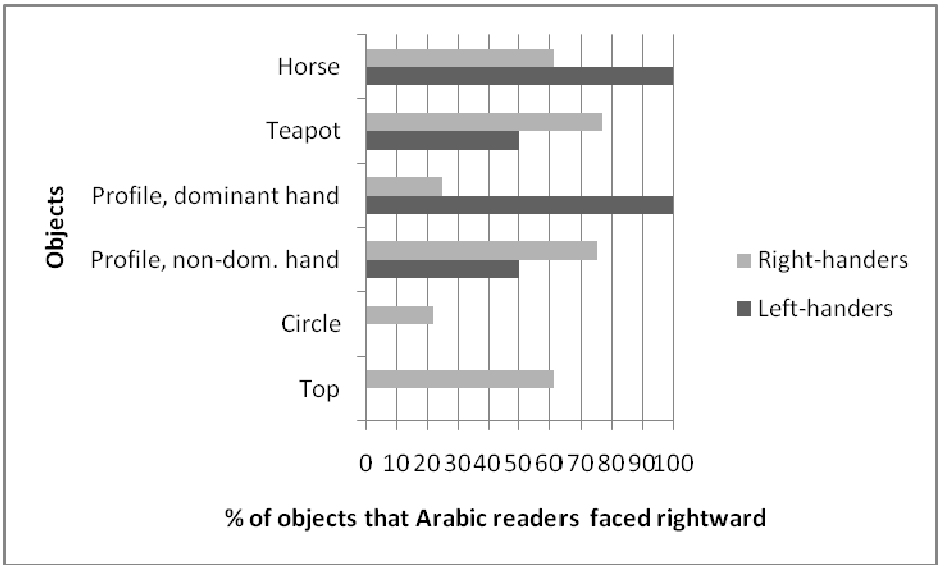

Figure 2. Directionality as a function of manual preference: Arabic readers.

Spatial positioning of objects in scenes

The scene items required participants to draw pictures consisting of multiple components, each possessing a unique spatial relationship with each other. This activity required spatial planning capabilities and the ability to schematically represent depth. The items included in this section were houses (one close, one far away), a car entering a garage, a car leaving a garage, three fish swimming in the same direction, and a sentence depiction ("the pen is between the candle and the stapler"). For the house item, the location of the near house was recorded. For the two car items, the direction in which the car was facing was recorded. Whereas the fish item was examined previously in terms of facing direction, for these analyses the item of interest was the order in which the fish were drawn (specifically, whether they were drawn in a left-to-right manner or a right-

to-left manner). For the sentence item, two observations were noted: the order in which the items were drawn and the position of the candle and stapler, relative to the pen.

In the house item (see Appendix 3, Figure 22), the majority of English-reading participants (85.9% of right-handers, 77.1% of left-handers) drew the scene with the near house on the left-side of the page. A chi-square analysis showed that manual preference did not have a significant influence on the position of the houses (X^2 = 1.324, p = .250). In contrast, the majority of Arabic-reading participants (61.9% of right-handers, 50% of left-handers) drew the scene with the near house on the right-side of the page. Again, a chi-square analysis showed that manual preference did not have a significant effect (X^2 = .198, p = .656). Reading/writing habits, however, did exert a significant influence on the position of the houses (X^2 = 22.022, p < .001). Whereas English readers preferred to draw the near house on the left, Arabic readers preferred to place it on the right.

In the car entering garage item (see Appendix 3, Figure 23), the majority of English-reading participants (59.3% of right-handers, 57.1% of left-handers) drew the scene with the garage on the right-side of the paper and the car moving rightward to enter it. Manual preference did not have a significant influence on the direction the car was entering (X^2 = .010, p = .919). The Arabic-reading participants were excluded from this item because there were not enough that drew the scene correctly.

For the car leaving garage item (see Appendix 3, Figure 24), the direction in which the car was leaving varied for English readers according to manual preference. The majority of English-reading right-handers (58.8%) drew the garage on the right-side of the paper and the car leaving the garage leftward, whereas the majority of English-reading left-handers (65.2%) drew the garage on the left-side of the paper and the car leaving the garage rightward. A chi-square analysis showed that manual preference had a moderate effect on the direction the car was leaving (X^2 = 3.173, p = .075), although the effect was not significant. The majority of Arabic readers tended to draw the garage on the right-side of the paper and the car leaving leftward (83.3% of right-handers, 100% of left-handers); there were no differences attributed to manual preference (X^2 = .194, p = .659). Overall, the general preference for both Arabic and English readers was to draw the car leaving leftward, and reading/writing habits did not exert a significant influence (X^2 = 2.299, p = .513).

Order of drawing the three fish

Referring back to the fish item (again, see Appendix 3, Figure 16), the majority of English-reading participants (70.8% of right-handers, 66.7% of left-handers) drew the fish starting on the far left and moving toward the right, in the order 1-2-3. The next most common order for English readers (12.3% of right-handers, 13.3% of left-handers) was to place the first fish in the center, the second fish to the right of center, and the third fish to the left of center, in the order 3-1-2. These two most common orders both

emphasize a left-to-right movement in drawing. A chi-square analysis showed that manual preference did not significantly affect the order in which the fish were drawn (X^2 = 2.716, p = .606). Arabic-readers also tended to draw the fish in the order 1-2-3 (25.0% of right-handers, 75% of left-handers), but right-handers were equally likely to draw the fish in order 3-2-1. While no effect of manual preference was found for Arabic-readers (X^2 = 4.598, p = .331), a separate chi-square showed that reading/writing direction did have a significant effect on the order in which the fish were drawn (X^2 = 25.996, p < .001).

Order of representing the three objects in a sentence

Participants on this task were to depict the following sentence: “the pen is between the candle and the stapler.” On this item (see Appendix 3, Figure 25), the majority of English-reading participants (50.7% of right-handers, 48.6% of left-handers) drew the three objects starting from the left and moving to the right, in the order 1-2-3. The second most common order (21.9% of right-handers, 21.6% of left-handers) was 2-1-3, where participants started in the center, drew the next item to the left-of-center, and the last item right-of-center. In both cases, the item on the far right was drawn last, emphasizing a left-to-right movement in drawing. A chi-square analysis showed that manual preference did not have a significant effect on the order in which the items were drawn (X^2 = 2.153, p = .828). Right-handed Arabic readers (50.0%) tended to draw the sentence items in the order 3-1-2. The next most common orders (18.2% and 12.5%, respectively) were 1-2-3 and 3-2-1. Left-handed Arabic readers were equally likely to

draw the items in the orders 1-3-2, 1-2-3, 3-2-1, and 3-1-2. Again, manual preference did not have a significant effect on the order of drawing (X^2 = 2.465, p = .792). For Arabic readers, the overall most common order was 3-1-2 (42.9%), and for English readers the most common order was 1-2-3 (51.3%). Interestingly, the Arabic readers' preference puts the last item drawn on the left, emphasizing a right-to-left movement, whereas English readers show the opposite movement by putting the last object on the right. Additionally, a chi-square analysis showed that reading/writing direction had a significant influence on the drawing order (X^2 = 37.437, p < .001).

The majority of English readers (91.1% of right-handers, 89.5% of left-handers) drew the candle on the left-side of the pen and the stapler on the right-side of the pen. Manual preference did not significantly influence the position of the sentence items (X^2 = .084, p = .773). In contrast, right-handed Arabic readers (84.6%) and left-handed Arabic readers (100%) tended to draw the candle on the right side of the pen and the stapler on the left-side of the pen, again emphasizing a right-to-left movement. There were no significant differences between right- and left-handed Arabic readers (X^2 = .355, p = .551). Although manual preference did not have a significant influence for Arabic or English readers, reading/writing habits did significantly influence the position of the candle (X^2 = 71.004, p < .001).

In summary, for scene depictions, there was a minimal effect of manual preference; the only item for which manual preference exerted a significant effect was the 'car leaving

the garage' item, and this effect was only observed for English readers. In contrast, there was a pervasive effect of reading/writing habits in arrange of objects in scenes. For each of the scenes (houses, object array in sentence, and swimming fish) Arabic readers tended to draw the first object on the right side of the page and proceed toward the left, whereas English readers tended to draw the first object on the left side of the page and proceed toward the right.

Aesthetic preference task

In the aesthetic preference task, participants took photographs of six objects in the most aesthetically pleasing orientation. For each photograph, the direction in which participants faced the objects was recorded. Similar to the drawing task, the items chosen for this task belonged to three categories: objects with implied motion, graspable objects, and a facial profile. The question of interest was whether manual preference would exert a significant influence on what participants considered visually pleasing. Data from this section are from 69 right-handed English readers and 38 left handed English readers.

Left-to-right orientation of objects with implied motion

The objects with implied motion consisted of an airplane, a car, and a rhinoceros. The preferred direction of facing for these items was determined to indicate the direction in which participants prefer to conceptualize motion.

The majority of participants (52.9% of right-handers, 58.3% of left-handers) photographed the airplane facing rightward (see Appendix 4, Figure 26). Manual preference did not have a significant influence (X^2 = .276, p = .599).

Similarly, the majority of participants (57.4% of right-handers, 63.9% of left-handers) photographed the car facing rightward (see Appendix 4, Figure 27). A chi-square analysis showed that manual preference did not have a significant effect (X^2 = .418, p = .518).

Lastly, for the rhinoceros item (see Appendix 4, Figure 28), the majority of participants (52.9% of right-handers, 52.8% of left-handers) photographed it facing rightward. There was no effect of manual preference (X^2 = .000, p = .987).

In summary, it is clear from these results that the majority of English readers, regardless of manual preference, prefer to face moving objects rightward, suggesting that they prefer to conceptualize motion from left-to-right.

Graspable objects

The graspable objects included a teapot and an iron. These items were taken from a previous study by Palmer et al. (2008) who had found a strong rightward orientation preference among right-handers (he did not test left-handers). We predicted that if

graspability is a relevant consideration in canonical depictions of objects (as suggested by Viggiano and Vannucci, 2002), preferred facing direction would differ according to participants' manual preference.

For the teapot item (see Appendix 4, Figure 29), the preferred viewing direction did vary according to manual preference. The majority of right-handers (51.5%) photographed the teapot with the handle positioned to the right, that is, in the side of space that right-handers would more easily pick up a teapot. In contrast, the majority of left-handers (72.2%) photographed the teapot with the handle on their left-side. A chi-square analysis showed that manual preference had a statistically significant influence (X^2 = 5.383, p = .020).

In contrast, the preferred viewing direction for the iron (see Appendix 4, Figure 30) did not vary according to manual preference. The majority of participants (52.9% of right-handers, 52.8% of left-handers) photographed the iron facing rightward, with the flat part on the right-side and the handle on the left-side of the iron. A chi-square analysis showed that there was no effect of manual preference (X^2 = .000, p = .987).

Profile/statue

For the statue item (see Appendix 4, Figure 31), the majority of participants (58.2% of right-handers, 61.1% of left-handers) photographed it facing rightward. A chi-square

analysis showed that manual preference did not have a significant effect (X^2 = .082, p = .775). Interestingly, this result is in direct contrast to that obtained for the drawing task, in which manual preference did exert a significant influence on the facing direction of the profile, suggesting that when the task involves actual motoric response, starting position and stroke sequence direction affect the outcome.

In summary, as Figure 3 illustrates, an overall rightward bias was found for English readers in the aesthetic preference task. The only object for which manual preference exerted a significant influence in aesthetic preference was the teapot—left-handers significantly preferred to orient the teapot with the handle on the left, whereas right-handers preferred the handle on the right.

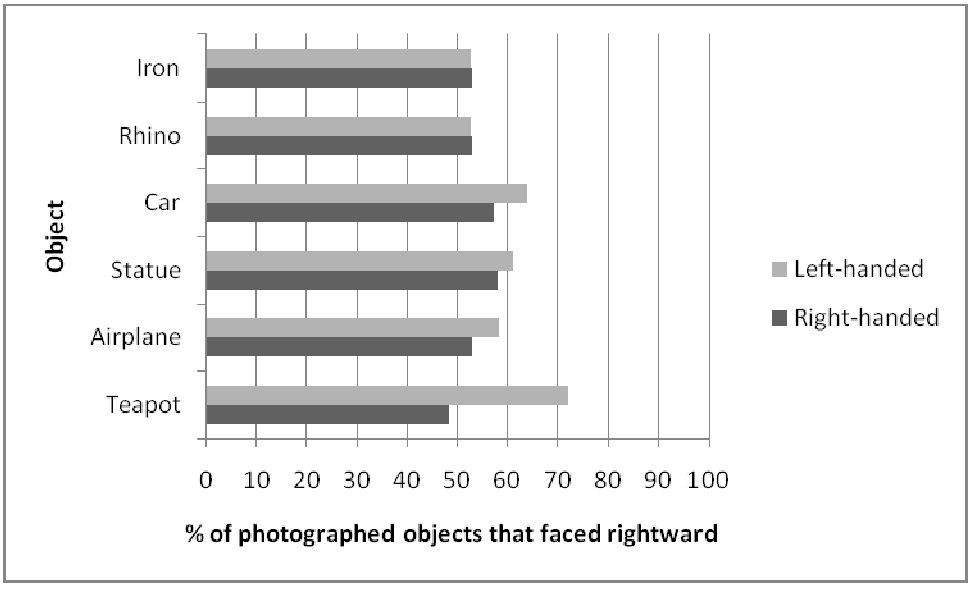

Figure 3. Effect of manual preference on direction of orientation in objects to be photographed.

Correlations between items in both the drawing and aesthetic preference tasks

Three items were included in both the drawing and aesthetic preference tasks: facial profile, teapot, and horse/rhino (for these analyses, the horse and rhino were considered the same). For these three objects, correlational tests were performed to see whether participants preferred to draw an object in the same spatial position as they prefer to view an object. The data for this section was collected from 69 right-handed English readers and 38 left-handed English readers.

For the profile/statue object, right-handers showed similar preferences for drawing and viewing. The slight majority of right-handers (57.4%) tended to draw the profile leftward and, likewise, preferred to take the photograph of the statue in the rightward facing position (58.8%) , with the subject's right-cheek displayed to the audience, r = -.064, p = .604. Left-handers also showed similar preferences for drawing and viewing. Left-handers preferred to draw the profile facing rightward (76.3%) and view the statue facing rightward as well (63.2%), r = .088, p = .600.

For the teapot object, right-handers again showed a difference in drawing and viewing preferences. Right-handers tended to draw the teapot facing rightward (70.6%), but showed a slight preference to view the teapot with the spout facing leftward (51.5%), r = .110, p = .371. In contrast, left-handers showed similar drawing and viewing preferences. Left-handers tended to draw the teapot with the spout facing rightward

(80.6%) and also preferred to view the teapot with the spout facing rightward (69.4%). This positive correlation did not reach significance (r = .284, p = .094).

Finally, for the horse/rhino object, right-handers showed a significant correlation between their drawing and viewing preferences. Right-handers preferred to draw the horse facing rightward (76.8%) and photograph the rhino facing rightward (53.6%), an effect that was statistically significant (r = .315, p = .008). Left-handers showed similar preferences, but the correlation did not reach significance. Most left-handers drew the horse galloping to the right (81.6%) and also preferred to view the rhino facing rightward (52.6%), r = -.043, p = .798.

In summary, the only significant correlation found was between the viewing and drawing preferences for the horse/rhino item, and the effect was only found for right-handers. Although left-handers showed a similar correlation for this item, the effect was much weaker and did not reach significance. These results are illustrated below in Figures 4 and 5.

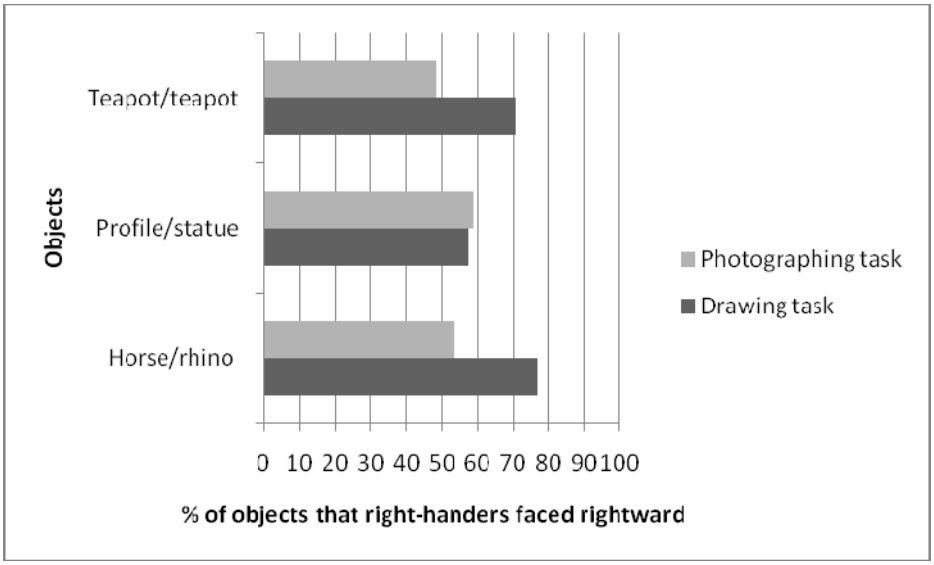

Figure 4. Correlation between English right-handers' drawing and viewing preferences for directional orientation of objects.

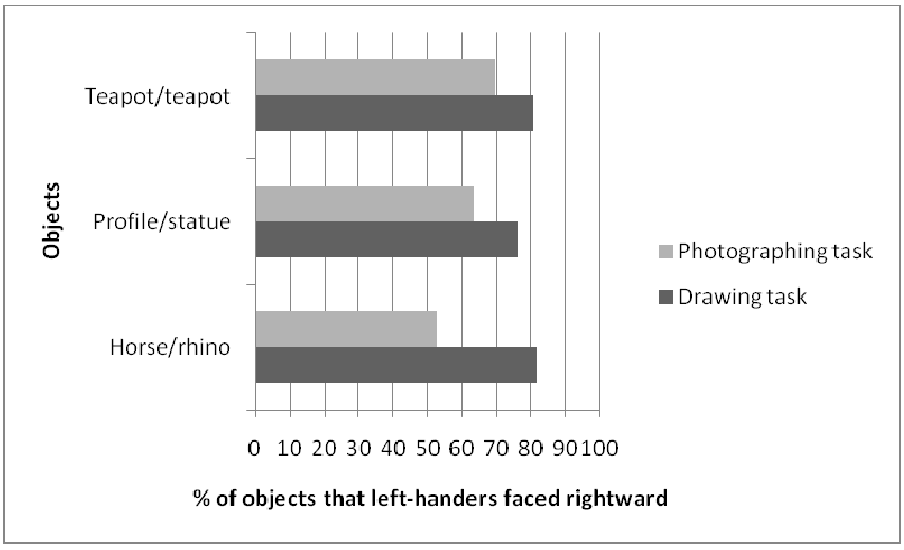

Figure 5. Correlation between English left-handers' drawing and viewing preferences for directional orientation of objects.

CHAPTER IV

CONCLUSIONS

We started our investigation by examining claims from prior research about the source of asymmetries observed in drawing directionality and aesthetic preference. Prior research (e.g., Alter, 1989) has tended to attribute drawing directionality effects mainly to cerebral laterality and has used manual preference as an indirect index of lateralization although the influence of reading/writing direction effects was acknowledged in principle. Few studies had examined non-laterality-based effects of manual preference (e.g., biomechanical differences relating to the ease of executing movements directed away from the body) and even fewer studies had investigated the interaction of reading/writing habits and manual preference. Finally, although it is clear that conventions regarding the drawing of particular kinds of objects or figures may come into play, there was little systematic examination of how subject matter of the to-be-drawn items may interact with the above variables.

A laterality account of drawing directionality would have predicted that right-handers and left-handers would show the same patterns for facing bias, but that right-handers would show the pattern to a stronger degree, as a result of their increased lateralization. The findings from our research do not support a laterality-based account since we obtained robust differences in drawing directionality as a function of handedness,

particularly for certain objects. The differences related to handedness observed in our study can be attributed, instead, to motoric factors (including starting point, stroke direction and sequencing, and use of the right or the left hand to draw) rather than to differences in cerebral laterality. In addition, we found support for cultural factors influencing drawing directionality of certain items. Motoric factors appeared primarily to influence the direction of facing of profiles, circles, and crescent moons, whereas reading/writing habits were the predominant influence for the sequencing of drawn objects in scenes, such as the near vs. far house, the three fish, and the order of drawing of the three objects mentioned in the sentence to be depicted. On the aesthetic preference task, which assessed preferred orientation of three-dimensional objects, we found no effect of manual preference, with one exception (the rhinoceros item) and, instead, found an overall left-facing preference. Taken together, these results suggest that additional factors besides lateralization influence drawing production, ambiguous figure perception, or aesthetically pleasing positioning of three-dimensional objects.

Ambiguous figure perception: A detection advantage for left-facing figures

The ambiguous figures task in the present research provided a test of whether left-facing or right-facing figures are detected first. In a recent study by McManus, Freegard, Moore, and Rawles (2010) a large database was reanalyzed to examine factors predicting interpretation of the duck/rabbit figure. McManus et al. (2010) found that the majority of males and females saw the duck (left-facing figure) first, but that “duck” responses decreased with age. More interestingly, they found that manual preference did not have a

significant effect on perception of the figure—both right- and left-handers in their extensive sample tended to see the duck first.

In the present study, as well, no effect of manual preference was found on the duck/rabbit figure or, for that matter, on the other ambiguous figures we included. Although McManus et al. (2010) did not examine the potential role of reading/writing direction in the detection of the duck or rabbit figure, our study found no difference between left to right and right to left readers. Instead, both groups showed an overall tendency to report seeing the left-facing figure for four out of the seven ambiguous pictures used in the study (duck/rabbit, angry man/liar, man/girl holding mirror, and Indian/Eskimo). The exception was the right-facing saxophonist/left-facing profile of woman ambiguous figure, for which there was a near significant effect of reading/writing direction: English readers reported seeing the woman first, whereas Arabic readers reported seeing the saxophonist first. Interestingly, we noted a similar effect of reading/writing habit in the facial profile drawing task, with Arabic readers more likely to produce rightward oriented profiles.

The left-bias found in ambiguous figure perception may indicate an actual perceptual bias for identifying left-facing figures in ambiguous displays or it may simply indicate that the left facing component of the ambiguous figures chosen for this study were perceptually more salient than the right facing component and thus that the figures were not truly ambiguous. In this study, we did not control for degree of ambiguity of the

stimuli. It may well be that some figures were just more readily detectable than others because of the way they were drawn, thereby masking any effects of variables such as handedness or reading/writing direction. For example, in the liar/angry man ambiguous figure, a very small number of participants (27 out of 145) were able to recognize the word “liar” at all. Thus it may be that potential effects of manual preference may have been obscured given that the two possible figures in many of the ambiguous stimuli were not equally salient.

Furthermore, given that we tested a fairly small sample of right-to-left readers (particularly left-handers among these), the lack of an effect of reading/writing habit may reflect the small sample size. To determine more conclusively whether there is an influence of reading/writing habits on perception of ambiguous displays, future research we plan to carry out will test a larger number of right- and left-handed Arabic readers. Another approach in future research that could shed light on the influence of reading/writing direction is to include readers of a script that is scanned and written from top to bottom, rather than horizontally.

This task could also be conducted by measuring speed of response. For example, instead of being asked to simply write down which figure they perceive first, participants could be asked to press a button as soon as they see the rightward facing figure. This would be an application of the method used in Viggiano and Vannucci (2002), in which the speed of identification of rightward vs. leftward facing perceptually degraded objects was

measured. Conducting the task in this way would more clearly indicate the instances in which the rightward facing figure is easier to perceive.

Directionality in drawing: Hand usage and reading/writing direction matter

The items in the drawing task belonged to one of two categories: objects and scenes. Within these categories, items varied along several dimensions, including graspability, animacy, and degree of implied motion. For individual objects the primary measure of interest was the direction in which the object was facing, but for scenes composed of multiple components, the arrangement and the order in which those components were drawn were of greatest interest. The overall trend for the drawing task was that manual preference primarily exerted an influence on individual objects (e.g., profile of a face, circle), while reading/habits seemed to influence the organization of scenes (e.g., near vs. far house, fish, sentence).

Reading/writing habits affect object positioning in scenes

Reading/writing habits appeared to have the strongest influence in the organization and arrangement of the components of a scene. In fact, for three out of the four scene items (sentence depiction, three fish swimming, near house vs. far house), reading/writing habits had a significant effect on the arrangement of the scene. Although both English and Arabic readers preferred to face the fish rightward, Arabic readers drew the fish in a right-to-left order. This suggests that, while other factors may be responsible for

determining the facing direction of the fish (starting point, stroke direction, etc.), reading/writing habits primarily influence the order in which the fish are drawn.

Our results for the sentence depiction item (which was adapted from a previous study by Knauft et al., 2007) suggest a clear influence of reading/writing direction on mental model representation. For the sentence item, participants were asked to draw the following sentence: “the pen is between the candle and the stapler.” Since “candle” is introduced before “stapler” it was of interest whether temporal precedence would align with scanning/movement bias, leading Arabic readers to place the candle on the right side and the stapler on its left, but leading English readers to show the opposite preference. Other research has also found effects of language direction on mental depiction of time (Boroditsky, 2003). Boroditsky found that Mandarin speakers use vertical metaphors to describe time, and are faster to confirm that March comes before April after they view a vertical array of objects, rather than a horizontal one. Likewise, English readers are faster after having seen a horizontal array of objects. This finding implies that the direction of the script in which one reads/writes influences the mental representation of directional concepts, such as time or size. In our task, the sentence mentioned the candle before the stapler, and English readers represented this by placing the candle to the left of the pen, whereas Arabic readers represented the candle as being to the right of the pen. It would be interesting to study whether readers of a vertical script would depict the items in a vertical array.

Similar to the sentence depiction task, reading/writing habits influenced the arrangement of the near vs. far house scene. English readers tended to place the “near” house on the left side of the page, whereas Arabic readers tended to place it on the right side. Again, this finding demonstrates the influence of script direction on mental representations of order and scale. English readers were more likely to imagine that they were standing on the left side of the page and looking rightward at the far away house, whereas Arabic readers showed the opposite preference.

The only individual object for which reading/writing habits had a near significant effect on the direction of facing was the crescent moon. English readers were more likely to face the crescent moon rightward, whereas Arabic readers were more likely to face it leftward. It was anticipated that similar results would be found between the moon and the circle items, and in fact the moon was merely considered to be a special case of the circle. However, in the circle item, no differences were found between English and Arabic readers—both preferred the counterclockwise orientation of the circle. It is unclear why reading/writing habits had a significant effect on the moon but not the circle, especially in view of the fact that if prior exposure to cultural symbols were a factor, one might have expected Arabic readers to draw a rightward facing moon, since that is how the moon is represented in flags and in the symbol of Islam. One possibility worth checking in future research is differences in starting position: if both groups (based on the circle drawing results) proceeded in a counterclockwise direction, it may

still have led to opposite orientation of the crescent moon if Arabic readers started the drawing from the bottom end while English readers started from the top end.

Manual preference and right vs. left hand use affect profile facing and circle drawing

The objects that showed a strong effect of manual preference were the facial profile and the circle. Taking the circle drawing results as a point of reference, and given that everyone started the profile from the forehead position, the results are straightforward: right-handed English readers, when using the right hand, proceed in a counterclockwise direction, which means the profile ends up facing left; the converse is true for left-handers. Furthermore, when right-handed English readers use their non-dominant hand, they behave like left-handers. These patterns reverse for Arabic readers. It is clear from these results that people have strong preferences for orienting facial profiles and circles, and that these preferences reinforce each other. The effect of using the dominant vs. non-dominant hand in drawing profiles was first examined by Crovitz (1962), whose results support the findings from this study: right-handers using their right hand drew significantly more leftward facing profiles, whereas right-handers using the left hand drew more rightward profiles

Our results from the circle drawing partially agree with the patterns found in Van Sommers (1984). We found that both right- and left-handed English readers showed an overall preference for counterclockwise drawing, but the strength of this preference was significantly stronger for right-handers. Similarly, Van Sommers observed that the

majority of right-handers preferred to draw the circles in a counterclockwise fashion, whereas the majority of left-handers used a clockwise direction. Glenn and Bradshaw (1995) found similar results, but also discovered a pattern of circle drawing preferences for right- and left-handers that changes over time. The youngest right-handers in Glenn and Bradshaw's study drew circles clockwise, whereas the youngest left-handers drew them counterclockwise. By age 5, right-handers reversed their pattern and both right- and left-handers showed a tendency to draw circles counterclockwise. However, by age 10, left-handers had switched to a clockwise preference. What is intriguing about these findings is that the respective tendencies of right-and left-handers—counterclockwise for right-handers, clockwise for left-handers—contradict the outcome expected from biomechanical influences. Because stroke directions directed away from the body are supposed to be easier to make than those directed inward, toward the body, and given that our study showed that people prefer to start the drawing at the top, one would expect right-handers to favor a clockwise direction and left-handers a counter-clockwise direction. However, the participants involved in Glenn and Bradshaw's study ranged from age 2 to 11, whereas the participants in our study ranged in age from 19 to 23. It is possible that the pattern that emerged in Glenn and Bradshaw evolves even more, and that the expected preferences emerge after participants acquire more experience.

Interestingly, there was no significant effect of manual preference or reading/writing habit for the direction of the spinning top, which was predicted to exhibit similar preferences as the circle. One explanation for the lack of significant differences between

right- and left-handers and English and Arabic readers in the spinning top example is that different cognitive processes are involved when people are to imagine objects in motion. In fact, for both of the drawing items that involved implied motion —namely, the horse and the fish—the preference was to orient the implied motion rightward, regardless of manual preference or reading/writing habits. Interestingly, the overall preference for the top spinning clockwise also implies a rightward direction of spinning, which is in accord with the preferred direction of motion for the fish and horse. Furthermore, a significant correlation was found between the direction of facing for the rhinoceros in the aesthetic preference task (rightward) and the facing of the horse (by the same participants) in the drawing task. In other words, our study suggests that people show a general preference to conceptualize and depict motion as moving from left to right, and this preference is uninfluenced by manual preference or reading/writing habits. These findings support those of previous research concerning the depiction of motion and drawing (Alter, 1989; Karev, 1999). The next question that arises from this finding is: how would such a universal pattern emerge? Future studies will attempt to clarify the origin of this pattern.

Aesthetic preference for facial profiles

The preference for motion that is directed from left-to-right is also evident in Western art. As Gross and Bornstein (1978) noted, movement depicted from left-to-right in art (see Figure 6) is seen as easier and faster, often representing an attack; in contrast, movement from right-to-left usually portrays withdrawal. The perceptual dominance of

the left-to-right movement may be explained by a cultural scanning bias (Gaffron, 1950), which proposes that people naturally enter a picture at the upper left side and move in a curved path toward the bottom right side. While this scanning bias is thought to be reversed for Oriental art, our study suggests that aesthetic preferences may not be so neatly divided between cultures. There was a widespread tendency to face items rightward in the drawing task, which implies that the rightward scanning bias may be more influential in drawing directionality than previously predicted. The predominance of rightward facing items in the photographing task also shows support for the rightward scanning bias; however, to strengthen this finding our future research will be repeated with members of an Oriental culture to determine whether they possess the opposite scanning bias.

Figure 6. The Rape of the Sabine Women, N. Poussin (1634-1635) Gross & Bornstein. Metropolitan Museum of Art, NY. The attacking figures are moving from left-to-right, whereas the weaker, withdrawing figures are facing leftward.

The results for the profile drawing supports past research that has shown clear patterns in the way people draw facial profiles. This strong trend for profiles may be a result of our brain's specialized areas for spatial processing. It may also be the product of biomechanical factors and the interacting preferences to start the profile drawing at the forehead and make stroke movements outward from the body—which results in opposite facing directions when opposite hands are used. Whereas manual preference significantly influenced the facing direction of profiles when they are drawn, the preference for viewing profiles in the photograph task, among English readers, was more universal. The majority of English readers, regardless of manual preference, took the photograph with the profile angled to the viewer's right, with the statue's right-cheek displayed. While this trend contradicts the trend found in McManus and Humphrey, it does agree with the outcome predicted by scanning biases. If people naturally move their gaze from left-to-right, then they may orient the face so that their gaze ends at the most interesting part of the face, where the eyes, nose, and mouth are located. Nevertheless, past research has traditionally attributed the prevalence of the leftward bias in portraits to cerebral dominance. Because the right-hemisphere is specialized for facial processing, facial information presented in the left visual field can be processed more readily, explaining why people often prefer portraits that face leftward. However, Cate (2002) proposed that the orientation that a portrait-sitter chooses to pose in depends on the amount of emotion they are trying to convey. Posing with the left-cheek displayed is thought to convey more emotion, whereas posing with the right-cheek displayed is interpreted as more serious and scientific. Because of the academic setting in which this

study was conducted, participants may have been more likely to orient the statue in the more serious pose. To test the influence of the desired emotional content, future research will indicate the amount of emotion participants should seek to convey.

Relationship between drawing direction and aesthetic preference

This study found no significant correlations between the facing directions for most of the drawn objects and photographed objects. It was predicted that, if no correlation existed between two items, then the graphic production and aesthetic preference of each item were governed by different cognitive processes. However, if there was a strong correlation between the facing directions of a drawing and photograph, then similar processes may be involved or an overall perceptual bias for that item may exist. The only significant correlation found was for the horse/rhino item. Left- and right-handers preferred to both draw the horse facing rightward and to photograph the rhino facing rightward, although the effect was only significant for right-handers. This unique finding may be attributed to object characteristics—the horse/rhino item was the only one of the series to contain implied motion. Whereas manual preference and reading/writing habits may exert differential effects for the drawing and photographing of the static teapot and facial profile items, scanning biases and a preference for left-to-right motion seems to influence the facing direction of drawing and photographing of objects with implied motion.

It will be important in future research to have a larger number of left-handed participants, among both readers of English and of Arabic scripts, and to test monolingual Arabic speakers, in order to strengthen and clarify the trends observed in this study. The fact that many of our Arabic participants were also familiar with English, may have weakened the effect associated with right-to-left reading/writing habits (as has previously been observed in other bidirectional readers, see review in Vaid, 2010). Likewise, the aesthetic preference task should be conducted with monolingual Arabic readers to ascertain how script direction and habitual scanning biases influence aesthetic preference in framing directional objects.

Conclusion

In summary, the results from this study suggest that a laterality approach does not fully explain the range of findings observed in drawing directionality and aesthetic preference. Directionality in drawing and aesthetic preference is likely a combination of several influences, including cultural factors, scanning biases, and starting point and stroke direction preferences, and the strength of each of these influences appears to vary depending on the nature of the subject matter itself.

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APPENDIX 1

Ambiguous figures used in Part I of the drawing task

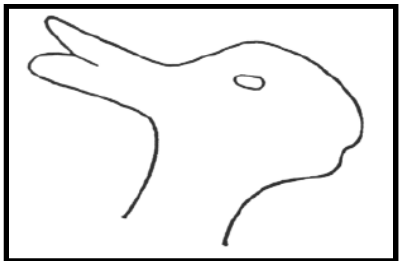


Figure 7. Duck/rabbit ambiguous figure (Duck facing left; rabbit facing right).

Figure 8. Saxophone/woman ambiguous figure (saxophone facing right; profile facing slightly leftward).

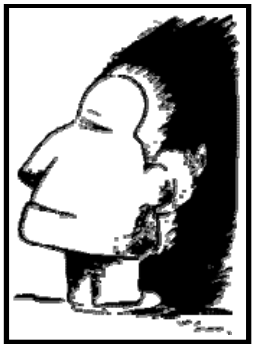


Figure 9. Native American/Eskimo ambiguous figure. The Native American is facing leftward; the Eskimo is facing rightward.

Figure 10. Angry man/liar ambiguous figure. The man is facing left; the word "liar" is aligned diagonally, from left to right.

Figure 11. White knight/black knight ambiguous figure. The white horses and knights are facing left, the black are facing right.

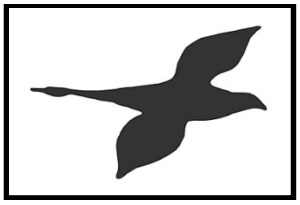


Figure 12. Goose/dove ambiguous figure. The goose is the leftward facing figure and the dove is the rightward facing figure.

Figure 13. Man/girl holding mirror ambiguous figure. The man is the leftward facing figure and the girl is the rightward facing figure.

Figure 14. Skull/woman ambiguous figure. The skull is the leftward facing figure and the woman is the rightward facing figure.

APPENDIX 2

TABLE 3
Summary table for ambiguous figure task

Ambiguous Figure:	**Language:**	**Figure seen first (left-facing or right-facing):**	**Manual preference:**	**Figure seen first (left-facing or right-facing):**
Duck/rabbit	English	Left-facing	*Right-handed*	Left-facing
			Left-handed	Left-facing
	Arabic	Left-facing	*Right-handed*	Left-facing
			Left-handed	---
Saxophone/woman	English	Left-facing	*Right-handed*	Left-facing
			Left-handed	Left-facing
	Arabic	Right-facing	*Right-handed*	Right-facing
			Left-handed	---
Angry man/liar	English	Left-facing	*Right-handed*	Left-facing
			Left-handed	Left-facing

TABLE 3 Continued

Ambiguous Figure:	**Language:**	**Figure seen first (left-facing or right-facing):**	**Manual preference:**	**Figure seen first (left-facing or right-facing):**
	Arabic	All reported seeing left-facing	*Right-handed*	All reported seeing left-facing
			Left-handed	---
White/black horses	English	Leftward facing	*Right-handed*	Left-facing
			Left-handed	Left-facing
	Arabic	Left-facing	*Right-handed*	Left-facing
			Left-handed	---
Goose/dove	English	Right-facing	*Right-handed*	Right-facing
			Left-handed	Left-facing
	Arabic	All (1) reported seeing right-facing	*Right-handed*	All (1) reported seeing right-facing
			Left-handed	---

TABLE 3 Continued

Ambiguous Figure:	**Language:**	**Figure seen first (left-facing or right-facing):**	**Manual preference:**	**Figure seen first (left-facing or right-facing):**
Man/girl holding mirror	English	Left-facing	*Right-handed*	Left-facing
			Left-handed	Left-facing
	Arabic	All reported seeing left-facing	*Right-handed*	All reported seeing left-facing
			Left-handed	---
Skull/woman	English	Left-facing	*Right-handed*	Left-facing
			Left-handed	Left-facing
	Arabic	Left-facing	*Right-handed*	Left-facing
			Left-handed	---
Indian/Eskimo	English	Left-facing	*Right-handed*	Left-facing
			Left-handed	Left-facing
	Arabic	Left-facing	*Right-handed*	Left-facing
			Left-handed	---

*No data was analyzed for Arabic left-handers because not enough valid responses were received.

TABLE 4
Percent of participants that oriented objects rightward

ITEMS		GROUP								TOTAL
		Rt-handed LR		Rt-handed RL		Lt-handed LR		Lt-handed RL		
Ambiguous figures	Duck/rabbit	N = 31	38.8%	N = 5	33.3%	N = 15	40.5%	N = 3	100%	N = 54
	Saxophone/woman	N = 24	31.6%	N = 10	71.4%	N = 17	44.7%	N = 1	33.3%	N = 52
	Indian/Eskimo	N = 7	9.7%	N = 1	6.7%	N = 1	2.9%	N = 0	0.0%	N = 9
	Angry man/liar	N = 78	97.5%	N = 0	0.0%	N = 36	94.7%	N = 0	0.0%	N = 114
	White/black knight	N = 6	11.5%	N = 2	33.3%	N = 7	26.9%	N = 0	0.0%	N = 15
	Goose/dove	N = 29	52.7%	N = 3	100.0%	N = 11	40.7%	N = 0	0.0%	N = 43
	Man/girl holding mirror	N = 3	3.8%	N=0	0%	N = 1	2.7%	N=0	0%	N = 4
	Skull/woman	N = 12	15.0%	N=3	20%	N = 3	7.9%	N=0	0%	N = 18
II. Drawing task										
A. Implied movement	Galloping horse	N = 46	57.5%	N = 13	59.1%	N = 24	63.2%	N = 4	100%	N = 87
	Fish	N = 54	67.5%	N = 14	63.6%	N = 26	68.4%	N = 3	75.0%	N = 97
B. Graspable	Teapot	N = 53	66.3%	N = 14	70.0%	N = 28	75.7%	N = 3	75.0%	N = 98

TABLE 4 Continued

ITEMS		GROUP								TOTAL
		Rt-handed LR		Rt-handed RL		Lt-handed LR		Lt-handed RL		
	Spinning top	N = 52	65.0%	N = 11	52.4%	N = 21	56.8%	N = 1	25.0%	N = 85
C. Circular shapes	Circle ending in an arrow	N = 11	15.9%	N = 2	12.5%	N = 14	40.0%	N = 1	25.0%	N = 28
	Crescent moon	N = 53	67.1%	N = 6	33.3%	N = 29	80.6%	N = 3	75.0%	N = 91
D. Profiles	Side profile, dominant hand	N = 34	42.5%	N = 7	31.8%	N = 28	73.7%	N = 3	75.0%	N = 72
	Side profile, non-dominant hand	N = 52	65.0%	N = 15	71.4%	N = 18	47.4%	N = 3	75.0%	N = 88
II. Photograph task (only administered to English readers)										
A. Implied movement	Rhinoceros	N = 36	52.9%	---	---	N = 19	52.8%	---	---	N = 55
	Airplane	N = 36	52.9%	---	---	N = 21	58.3%	---	---	N = 57
	Car	N = 39	57.4%	---	---	N = 23	63.9%	---	---	N = 62
B. Graspable	Teapot	N = 33	48.5%	---	---	N = 26	72.2%	---	---	N = 59
	Iron	N = 36	52.9%	---	---	N = 19	52.8%	---	---	N = 55
C. Profile	Nefertiti statue	N = 39	58.2%	---	---	N = 22	61.1%	---	---	N = 61

*Note. For the house item, facing rightward means that the near house was drawn on the right side of the page.

TABLE 5
Comparison of percent right facing of drawn vs. photographed items

	Teapot		Horse/rhino		Profile/statue	
	Correlation statistic	p-value	Correlation statistic	p-value	Correlation statistic	p-value
Right-handers (n = 68)	r = .110	p = .371	r = .315	p = .008	r = -.064	p = .604
Left-handers (n =	r = .233	p = .165	r = .013	p = .937	r = .139	p = .398

TABLE 6
Percent of participants that oriented scenes rightward

ITEM	GROUP								TOTAL N
	Rt-Handed LR		Rt-Handed RL		Lt-Handed LR		Lt-Handed RL		
House	N = 11	14.1%	N = 13	61.9%	N = 8	22.9%	N = 2	50%	N = 34
Car entering garage	N = 16	59.3%	N = 1	50%	N = 4	57.1%	N = 0	0%	N = 21
Car leaving garage	N = 14	41.2%	N = 1	16.7%	N = 15	65.2%	N = 0	0%	N = 30

Note. For the house item, rightward facing means the near house is on the right side of the paper.

APPENDIX 3

Example objects/scenes used in drawing task

Objects

Figure 15. Horse object, coded as facing rightward.

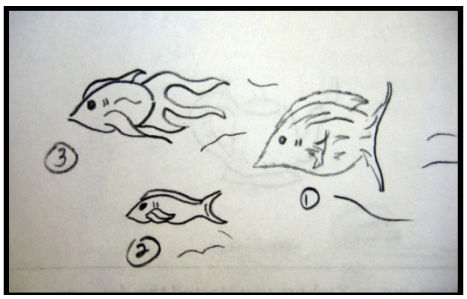


Figure 16. Fish object/scene, coded as facing leftward.

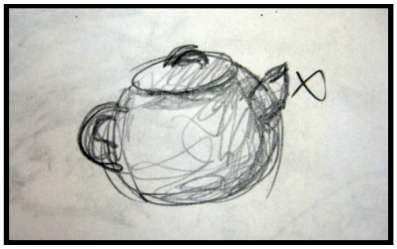


Figure 17. Teapot object, coded as rightward facing.

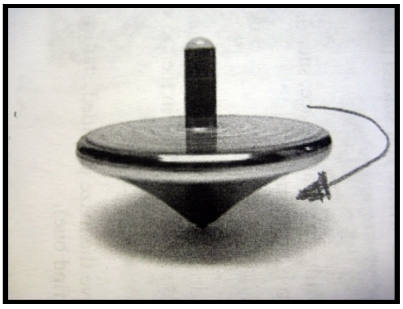


Figure 18. Spinning top object, coded as oriented clockwise.

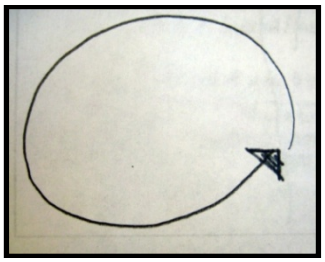


Figure 19. Circle object, coded as oriented counterclockwise.

Figure 20. Moon object, coded as rightward facing.

Figure 21. Profile object, coded as rightward facing.

Scenes

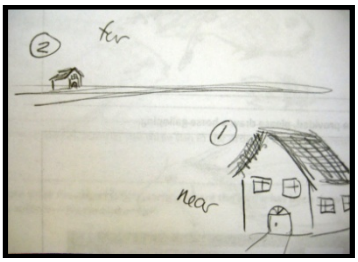


Figure 22. House scene, coded as near house on the right side.

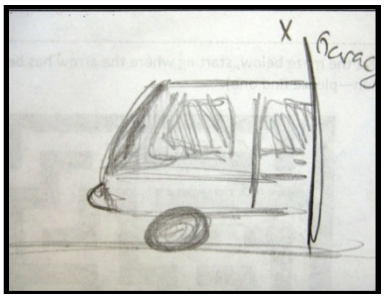


Figure 23. Car entering garage scene, coded as entering rightward.

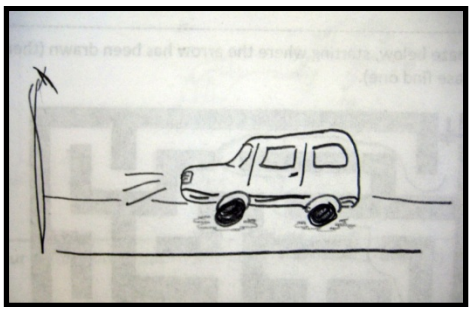


Figure 24. Car leaving garage scene, coded as leaving rightward.

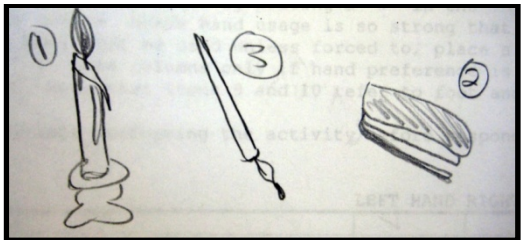


Figure 25. Sentence depiction scene, coded as 1-3-2.

APPENDIX 4

Examples of objects used for the aesthetic preference task

Figure 26. Photograph of airplane from aesthetic preference task, coded as facing rightward.

Figure 27. Photograph of car from aesthetic preference task, coded as facing leftward

Figure 28. Photograph of rhinoceros from aesthetic preference task, coded as rightward facing.

Figure 29. Photograph of teapot from aesthetic preference task, coded as rightward facing.

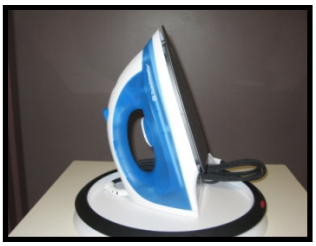


Figure 30. Photograph of iron from aesthetic preference task, coded as facing rightward.

Figure 31. Photograph of statue from aesthetic preference task, coding as facing rightward.

APPENDIX 5

HANDEDNESS QUESTIONNAIRE

NAME: _____ M/F AGE: ____

INSTRUCTIONS: Please indicate your preferred hand usage in the activities listed below by placing a "+" in the appropriate column. Where hand usage is so strong that the other hand would not be used unless forced to, place a "++". Place a "+" in both columns only if hand preference is truly indifferent. Note that items 9 and 10 refer to foot and eye usage.
Imagine yourself performing the activity before responding to each item.

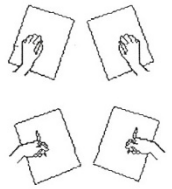
ACTIVITY	LEFT HAND	RIGHT HAND
1. Writing		
2. Holding a nail when hammering (which hand holds the nail)		
3. Throwing a ball		
4. Using a toothbrush		
5. Cutting with scissors		
6. Combing your hair		
7. Threading a needle (which hand holds the needle)		
8. Pouring liquid into a bottle (which hand holds the bottle)		
9. Kicking a ball (which foot)		
10. Looking into a camera (which eye)		

1. Do you consider yourself to be ____ left-handed
____ right-handed
____ ambidextrous

2. Are there any members in your immediate family who are left-handed? ____ Yes ____ No If yes, specify who:
_____

3. Have you ever changed your handedness? ____ Yes ____ No
If yes, please indicate when and why _____

4. Refer to the diagram below and circle which hand position you use when writing.



6

APPENDIX 6

B

Language Background Questionnaire 2009

Name:_____ Male or Female Age:_____ Email:_____

What is your first spoken language? _____

In the table below, please write:

a) Each language you speak or have studied
b) When you started learning/speaking each language(s): 0-4 yrs / 5-8 yrs / 9-12 yrs / above 12 years
c) Where you studied/spoke each language: At school / At home / Both home and school / Only with friends / Other (specify)
d) How long you studied each language in school: e.g., 5 years 3 months).

Language (list each language you know)	Age Acquired (0-4yrs;5-8yrs;9-12yrs;after 12 yrs)	Where Learnt (school; home; both; other)	How Long Studied (In years and months; e.g., 5 yrs 6 months)

What language or languages do you mostly use when speaking with each of the following:

a. Your parents _____
b. Brothers or Sisters _____
c. Grandparents _____
d. Friends _____
e. Teachers _____
f. Others (specify)_____

In which language or languages do you typically:

a. Express affection _____
b. read a newspaper _____
c. Pray _____
d. Dream _____
e. Think _____
f. Mentally add, multiply _____
g. Tell funny stories _____
h. read a novel _____
i. Send email _____
j. send handwritten letters _____
j. Curse _____
k. Keep a diary (if applicable) _____

When speaking with others who know two or more languages that you know, how often do you switch back and forth from one language to another?

Never Rarely Sometimes Frequently All the time

For each of your languages, please rate how well you understand, speak, read and write is, using the scale below:

1= very poorly 2=poorly 3=below average 4=average 5=above average 6= well 7=very well

Language	Understanding	Speaking	Reading	Writing

CONTACT INFORMATION

Name:	Rebecca Elizabeth Rhodes
Professional Address:	c/o Dr. Jyotsna Vaid Department of Psychology Texas A&M University College Station, TX 77843
Email Address:	rrhodes@tamu.edu
Education:	B.S., Psychology, Texas A&M University, May 2010 Summa Cum Laude Honors Undergraduate Research Fellow